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TEXTILE RESEARCH JOURNAL

VOL. XVIII, No. 1 January, 1948

A Few Experiments on the Crystallinity of Polyamides

M. E. Bergmann, I. Fankuchen, and H. Mark

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CAROTHERS and HILL [1] observed, immediately after the synthesis of the first polyamides, that these polymers have a strong tendency to crystallize and that their crystallites can be oriented by drawing. The resulting fiber diagrams were first studied by Brill [2] and later more extensively by Fuller, Baker, and their collaborators [3, 4]. It was found that upon cooling a polyamide melt in the absence of external stress or shear, a mass of randomly arranged spherulites is formed, each of which consists of a large number of small, highly anisotropic crystallites. These crystallites, ordered areas, or domains of high lateral order are arranged radially in the spherulite and produce its characteristic pattern of extinction between crossed polaroids. They are embedded in a matrix of amorphous or disordered material and produce an x-ray pattern exhibiting a number of uniform rings, the diameters of which are characteristic for the three-dimensional arrangement of the chain molecules in the ordered domains [3]. The width of the diffraction circles is related to the average size and shape of the crystallites and depends essentially upon the rate at which a given polyamide is allowed to go from the disordered into the ordered state. Any factor which favors lateral order, such as regular structure of the individual chain molecules, strong intermolecular attraction, slow rate of cooling or prolonged annealing, leads to the development of larger crystallites or better lateral order and, hence, sharper diffraction circles. On the other hand, Fuller, Baker, and their collaborators [4] have demonstrated that an irregular arrangement of the laterally attractive (CONH)-groups or their partial replacement by ($CONCH_3$)-groups disfavors the establishment of larger domains of high lateral order and, as a consequence, leads to structures which have broader diffraction rings. Recently Wittbecker reported the preparation and investigation of a number of substituted polyamides which have been used to produce fibers with a low modulus and a high range of reversible elasticity—the so-called "elastic nylons" [5].

This indicates that inhibiting crystallization tends to produce rubbery materials with low modulus and high extensibility, whereas treatments or conditions which favor crystallinity lead to high-modulus, low-elongation products [5]. In this paper, we shall describe experiments on nylon samples which were subjected to swelling in a dilute aqueous phenol solution and which, as a result, assumed a high degree of crystallinity. Their degrees of crystallinity, as well as any preferred orientation, were examined by means of x-ray diffraction diagrams, while at the same time their mechanical properties were tested by cold drawing under controlled conditions.

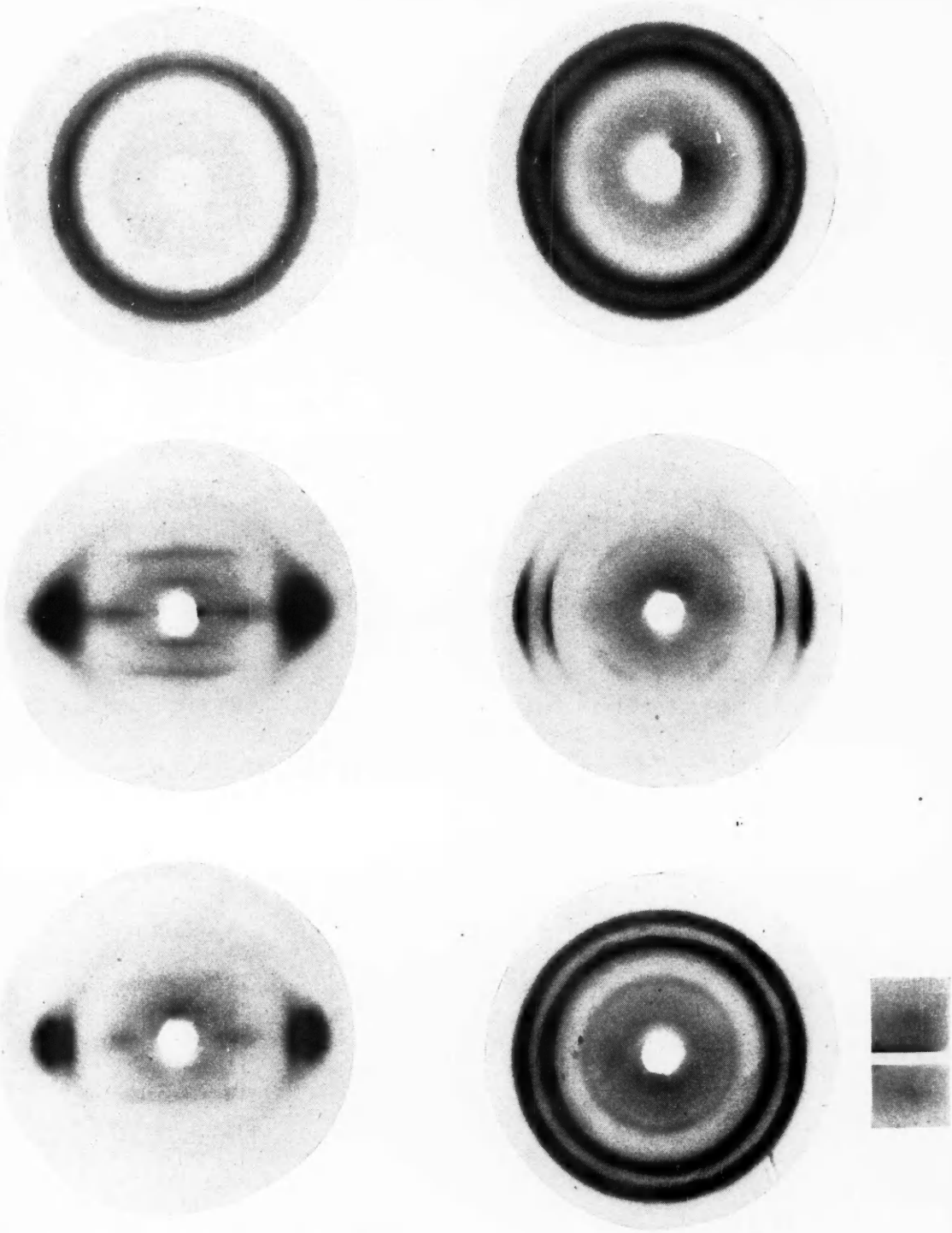

FIG. 1 (*top*). *Commercial undrawn multifilament nylon yarn.*

FIG. 2 (*center*). *Multifilament nylon yarn drawn by hand to about four times its original length.*

FIG. 3 (*bottom*). *The same sample as that in Figure 2, annealed at 180°C for 36 hours; tension relaxed.*

FIG. 4. *Swollen nylon monofils. Top to bottom: A—swollen for 36 hours; B—drawn by hand and then swollen for 60 hours; C—drawn by hand and then swollen for 3 weeks; D—small-angle pattern of same sample as C.*

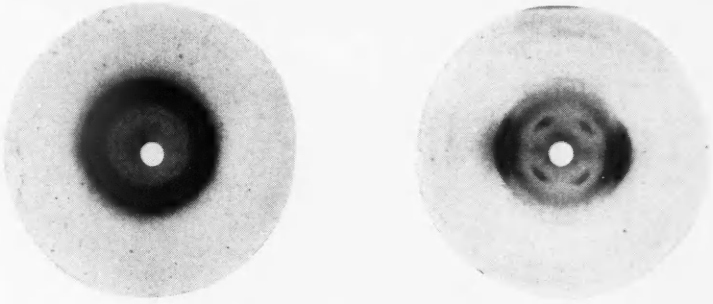

FIG. 5. *Drawn monofil with neck. Patterns obtained with microcamera. A (left)—At portion having original diameter. B (right)—At portion having reduced diameter.*

Experimental Procedure

All samples investigated were commercial 6,6-nylon in the form of undrawn monofils and multifilament yarns.

The drawing was carried out by hand or in a Scott testing machine; the mechanical properties of the samples were determined in the same machine.

X-ray diagrams were taken with commercial x-ray equipment producing Cu-radiation. In general, Ni-filtered radiation was used; if necessary, the primary beam was monochromatized by reflection on the 002 face of a pentaerythritol crystal. Normal flat-film diagrams with 5-cm. specimen-film distance were taken of all samples; they were supplemented in some cases by small-angle diagrams with 50-cm. specimen-film distance and by microdiagrams.

The swelling of the specimens was carried out at room temperature without excluding air or oxygen; after the swelling period, the samples were washed, then dried and conditioned overnight at a temperature of 70°F ± 1°, the humidity being 65 ± 1 percent.

Axial and Lateral Order

Figure 1 shows a typical x-ray diffraction pattern of a commercial undrawn multifilament nylon yarn. The most prominent ring shows a poorly resolved doublet structure; there are at least one ring farther inside and one farther outside, but in the reproduction these are not clearly visible. There is no indication of any axial orientation of the ordered regions. The moderate sharpness of the diffraction rings indicates the presence of laterally ordered domains of moderate size. In addition, a diffuse background, most prominent near the center of the diagram, is characteristic of this and all other diffraction patterns shown in this paper. This diffuse background is not only the result of remaining white x-radiation, as was shown by means of a control photograph (not reproduced here) with radiation which had been monochromatized by reflection from the 002 face of a pentaerythritol single crystal. In our opinion, this diffuse background is caused, at least in part, by the amorphous material which is presumably present between the crystallized regions.

Because of the poor resolution of the most prominent double ring, this pattern is not very suitable for the measurement of lattice constants. If two maxima are separated only slightly more than twice the halfwidth of their profiles, then the maxima are displaced toward each other as compared with the locations they would have in the absence of superposition. This effect is illustrated very well in the photometric curves of diagrams of fibers quenched at different temperatures which were published by Fuller, Baker, and Pape [3]. In the patterns shown in Figure 4, the improved crystallinity of the sample and the reduced halfwidth of the lines lead to a greater apparent lattice distance.

Figure 2 shows the diagram of a multifilament yarn which was drawn by hand to about four times its original length. Patterns of single fibers drawn under controlled loads are shown and discussed in the section on mechanical properties of nylon monofils. Figure 2 shows almost complete axial orientation of the ordered regions. While the lateral order, as indicated by the radial width of the principal rings, is even poorer than in Figure 1, the double ring has contracted almost completely into two short arcs in the equatorial plane, which show no evidence of resolution of the double structure. Inside, the faint ring of Figure 1 has given way to two layer lines corresponding to a lattice constant of 8.5 Å. Farther inside, two additional layer lines are visible, which indicate an identity period along the fiber axis of 17.1 Å. (See Table I.)

If the drawn yarn is annealed at 180°C for 36 hours with the tension relaxed, orientation remains

TABLE I. LOCATIONS OF SPOTS, ARCS, AND LAYER LINES IN X-RAY PATTERNS OF ORIENTED NYLON

Layer lines	Equatorial arcs
17.5 Å. (approx.)	4.4 Å.
8.5 Å.	3.9 Å.
3.5 Å.	2.4 Å.
2.5 Å.	

	Spots	
Additional meridian arc	Vertical component	horizontal *
2.3 Å.	17.1 Å.	18.8 Å.
	8.5 Å.	9.4 Å.

* The horizontal components of the spots are ξ-values on the Bernal chart, converted into Angstrom units.

unchanged and the lateral order is improved. The x-ray diffraction pattern is shown in Figure 3. It will be noted that the layer lines have about the same appearance as in Figure 2, and that the equatorial arcs have not lengthened. But the doublet structure of the strongest reflection is clearly visible in Figure 3.

Figure 4 shows a number of diffraction patterns of nylon monofils which have been soaked in a dilute aqueous solution of phenol. Figure 4A was obtained from an undrawn monofil which had been soaked in a water-phenol mixture for 36 hours. Compared with Figure 1, it shows better lateral order (reduced radial line width), but otherwise little change. Figure 4B was obtained from a monofil which had been drawn by hand (like that in Figure 2) and then been soaked in the phenol solution for 60 hours. Comparison with Figure 2 shows drastic changes: the layer lines are now split into four fairly short arcs the vertical coordinate of which still corresponds to a lattice constant along the fiber axis of 8.5 Å. The innermost spots cannot be recognized above the diffuse background in this diagram. The principal arcs are now neatly separated, but are much longer than in Figures 2 and 3. Obviously, soaking, while improving lateral order a great deal, has at the same time reduced axial order considerably.

Figure 4C is the diagram of a monofil which was first drawn and then soaked in the phenol solution for 3 weeks. The axial orientation has almost completely disappeared, while the lateral order is very good, even better than that in Figure 4A.

Finally, Figure 4D [6] shows a small-angle pattern of the same fiber as that shown in Figure 4C. The fairly sharp spot visible on this pattern corresponds to a repeating distance of about 140 Å. The fiber was held so that the details shown correspond to the meridian plane of the oriented specimens.

Further diagrams of soaked fibers are shown in Figures 10B and 10D. The time of soaking had been 36 hours in both cases, and comparison with Figure 4B reveals somewhat better axial orientation, as indicated by the shorter arcs.

Figures 5A and 5B were obtained in a microcamera from one fiber, the same one which had been drawn by hand and then soaked for 36 hours. When a single fiber is drawn slowly at room temperature, a neck forms, which travels along the fiber as drawing is continued. Above the neck, the diameter of the fiber is not changed at all, whereas below the neck, it is cut to about one-half. Before the neck had traveled to the end of the specimen, the drawing was discontinued and the whole fiber was soaked. Figure 5A was taken from a portion above the neck; Figure 5B from one below. There is close similarity between these two diagrams and those of Figures 4A and 4B, respectively. The ring immediately inside the inner of the two principal rings should be disregarded; it is caused by K_β-radiation, which was not filtered out in this instance.

Just outside the shadow of the center lead stop, it is possible to see four spots which are leftovers from the innermost set of layer lines of Figure 2; in Figure 4B, these spots are masked by the diffuse background.

Figures 5A and 5B also show some details outside the principal rings, which represent higher-order reflections. The rings of Figure 5A correspond to the long arcs in Figure 5B. In addition, Figure 5B shows one set of meridian arcs and one set of equatorial arcs, which are not observable in Figure 5A.

Microdiagrams (not reproduced here) were also taken of fibers which were annealed for 36 hours at 180°C after soaking. No change was observed in the x-ray pattern. Subsequently the same fiber was stretched to a higher draw ratio by hand. Except for the reappearance of very faint layer lines like those of Figure 3 no further change was observed upon additional stretching.

An attempt was made to compare the various diagrams shown in Figures 1 to 5 in order to ascertain whether there was any evidence of a pattern representing a solvated form of nylon. It was pointed out above that the two principal maxima of the diagrams appear to recede slightly from each other. Except for this effect, no ring, arc, or spot of the pattern

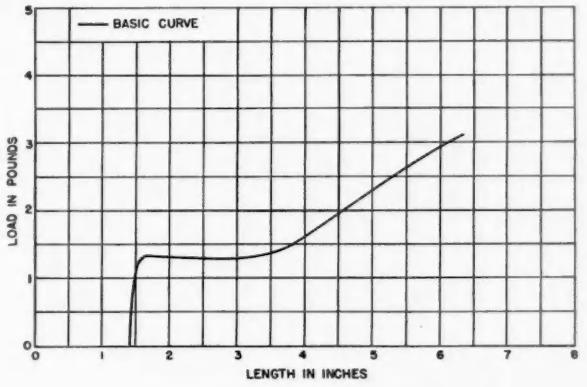

FIG. 6.

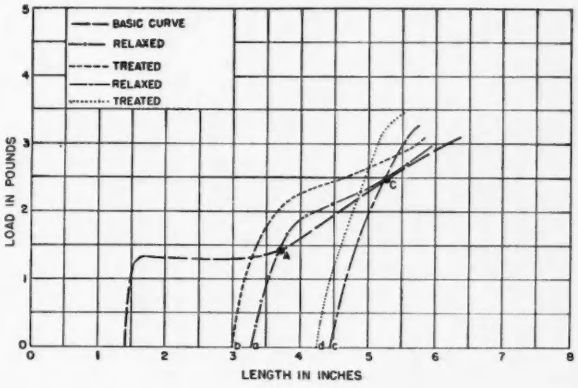

FIG. 7.

changed its location so as to indicate the emergence of a new lattice. The conclusion was reached, therefore, that soaking affects the texture of the crystalline-amorphous system in a manner similar to annealing, in that it promotes the elimination of lattice distortions in the ordered regions and enables these regions then to increase in size. No change in the crystal structure can be observed. If this assumption is tentatively accepted, then it is possible to obtain a certain amount of crystallographic information through combining the information revealed by the various diagrams.

The innermost layer lines of Figure 2 lead to an identity period along the fiber axis of 17.1 Å. All other meridian reflections with the exception of the outermost arc in Figure 5B correspond very nearly to this length divided through by an integer. The principal equatorial arcs correspond to lattice constants of 3.8 Å. and 4.6 Å., respectively. The horizontal component of the four prominent spots corresponds to a length of 9.4 Å. This quantity represents a lattice constant only if the unit cell is orthogonal; otherwise a more careful analysis with additional data is necessary. The innermost faint spots of Figure 5B cannot be measured accurately, but appear to correspond to twice the vertical and horizontal distance of the prominent spots.

There remains the outermost meridian arc in Figure 5B. A clue for its interpretation seems to be provided by a very faint layer line visible on the original film of Figure 2. This layer line intersects the meridian at the location of the inner one of the two faint arcs of Figure 5B, and it has the expected slight, outward curvature. Its ends, which appear to be slightly accentuated, are located at the intersection between the layer line and the outermost arc of Figure 5B. The arc of Figure 5B could, therefore, be explained as the result of imperfect orientation of the fiber. The evidence at hand does not permit a reliable decision on this point.

Mechanical Properties of Nylon Monofils

In order to see whether there is any distinct correlation between the changes in texture as revealed by the x-ray diffraction patterns and the mechanical properties of the fibers, a series of load-elongation curves was obtained on a Scott tensile-strength testing machine. In all cases, the tests were preceded by a conditioning period of at least 24 hours in the air-conditioned room in which the testing machine was located. In some of the tests, the fibers were steadily elongated until they broke; in others, they were first drawn up to a certain point, then the tension was relaxed, sometimes phenol treatment was applied, and the samples were then redrawn. In all tests, the motor driving the machine was slowed down by a rheostat to a speed at which the jaws were moving apart at a rate of approximately 0.4 mm./sec. (0.016 in./sec.). Because of slippage, dye marks were applied directly to the test specimens at the beginning of the run directly at the jaws, and the distance between the marks was recorded rather than the distance between the jaws.

The curves obtained by steady drawing (until the breaking point is reached) will in the remainder of this section be referred to as load-elongation curves. Approximately half of the fibers tested in this manner had been previously soaked in a phenol-water mixture for 36 hours, whereas the remainder merely had been conditioned in the constant temperature-humidity room. No consistent differences in me-

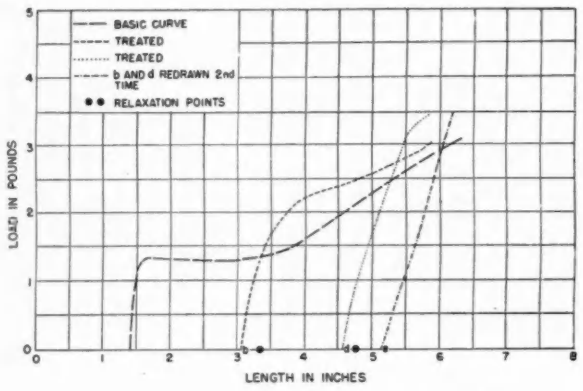

FIG. 8.

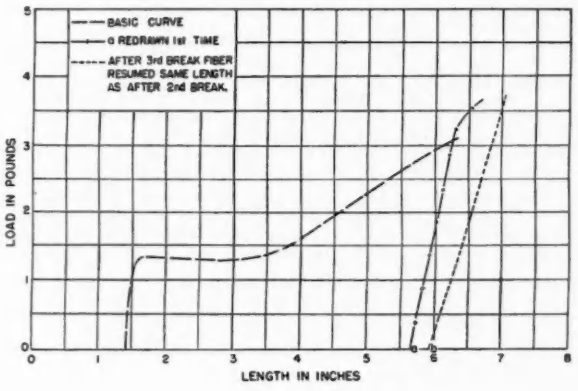
BASIC CURVE
a REDRAWN 1st TIME
AFTER 3rd BREAK FIBER RESUMED SAME LENGTH AS AFTER 2nd BREAK.
LOAD IN POUNDS
LENGTH IN INCHES

FIG. 9.

chanical behavior could be discovered between these two classes of samples, and they will, therefore, be described together. The load-elongation curves show three distinct parts (Figure 6):

1. The load increases rapidly with but slight elongation and reaches a first maximum at about 1.3 pounds at an elongaton not in excess of 20 percent. Since the initial cross section of the fibers was 2.75×10^{-4} square inches, this maximum corresponds to a stress of about 5.5×10^{3} lbs./sq. in.

2. After a slight decrease, the load remains constant until an elongation between 200 and 250 percent has been reached. Observation of the fiber failed to reveal the formation of a neck, although in more rapid and less homogeneous drawing at least one neck and its travel across the whole length of the stretched fiber is invariably observed.

3. The load again increases and rises almost linearly with the elongation until the fiber breaks. While the slope in this third part varies considerably from specimen to specimen, it is of the order of 1.5 pounds per 100 percent increase in elongation. The first break occurred always outside the dye marks, at loads from 2.75 to 3.75 pounds. It appears reasonable to assume that in the experimental arrangement which was used this break occurred at a point where the fiber was damaged while slipping through the jaws and that no intrinsic significance should be attached to the observed breaking loads.

It is interesting that in the slow, controlled drawing, as carried out on a testing machine, no neck was ever observed, in contrast to the more rapid and less even drawing by hand. Fiber diameters were regularly determined at the beginning and at the end of each run. It was generally found that the product of length and cross section changed only by amounts within the limits of error in the measurements, and, furthermore, that the diameter of any one specimen after drawing was remarkably constant throughout the length of the fiber, varying only about 1 percent of the mean.

An attempt was made to assign a Young's modulus to the initial, fairly straight portion of the load-elongation curve. Considering the poor accuracy of the readings in this steep section and the variability from specimen to specimen only an estimate of the true value can be given: the average of all experiments gave $(0.9 \pm 0.2) \times 10^{5}$ lbs./sq. in.

After these drawing experiments, a series of tests was performed in which the tension was relaxed at a predetermined point of the curve and the test was then resumed either with or without intermediate phenol-water treatment. Altogether, four different procedures were followed, the resulting curves of which are shown in Figure 7:

(*a*) The tension was relaxed at point *A*, at the end of the second part of the curve. Drawing was then resumed without intermediate treatment. The behavior thus obtained is shown as curve *a* in Figure 7. It will be noted that there is some relaxation between the point at which drawing was first interrupted and the length of the specimen at zero load. When tension is slowly reapplied, the curve rises at first linearly to a point slightly above the basic load-elongation curve and then bends down toward this curve. There is some evidence that the linear portions of curve *a*, and also those of curves *b*, *c*, and *d*, correspond to reversible, elastic deformation; for if the tension is relaxed anywhere along this linear portion, the fiber snaps back very nearly to the starting point.

Young's modulus corresponding to the steep rise

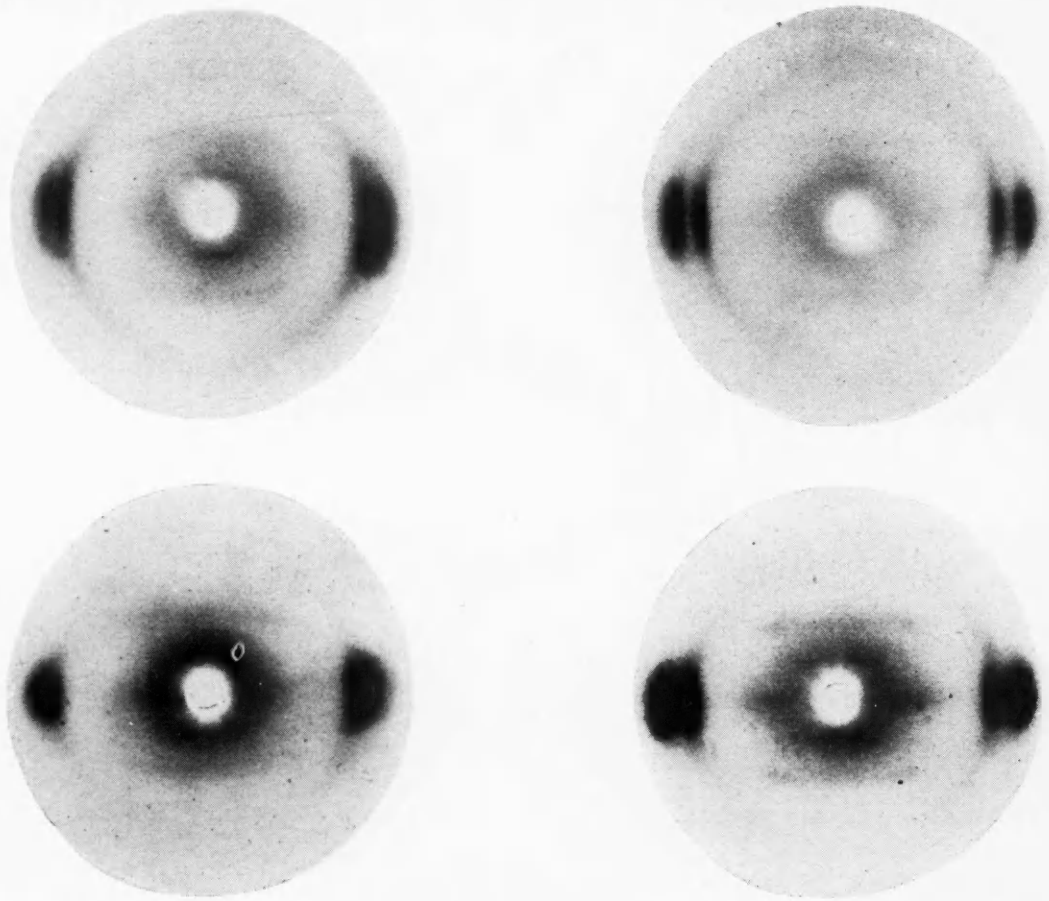

FIG. 10. *A (top, left)—Monofil drawn to point* A *of Figure 7. B (top, right)—Monofil drawn to point* A, *then soaked and reconditioned. C (bottom, left)—Monofil drawn to point C. D (bottom, right)—Monofil drawn to point C, then soaked and reconditioned.*

is about $(4 \pm 1) \times 10^5$ lbs./sq. in., the fluctuations again representing variation from specimen to specimen rather than measuring inaccuracy. The stress at the top of the linear portion is about 25×10^3 lbs./sq. in. This shows that both Young's modulus and the elastic limit of a drawn specimen are very much larger than the corresponding values for the undrawn fiber. This change in mechanical properties is accompanied by a change in texture revealed by the x-ray patterns. Figure 10A shows the diagram taken at the point of relaxation. The orientation is quite good, but the lateral order is apparently poor, as shown by the radial width of the principal arcs.

(*b*) Tension was again relaxed at point *A* of Figure 7, but the fiber was soaked and reconditioned before redrawing. Figure 10B shows the x-ray diagram obtained after the phenol-water treatment. The radial resolution is very much improved over that of Figure 10A, and the orientation is also somewhat improved, as shown by the disappearance of the inner ring away from the equatorial plane. Apparently, the phenol treatment leads to growth of the already existing oriented crystals.

A typical load-elongation curve obtained with this procedure is shown as curve *b* in Figure 7. The fiber has shortened beyond the point of relaxation of curve *a* as a result of the phenol treatment. Upon redrawing, a curve is obtained which is similar to curve *a* but shows a somewhat higher elastic limit.

(*c*) Curve *c* of Figure 7 was obtained by initial drawing to point *C* on the basic curve—that is, to a load of 2.5 pounds, well beyond the constant-load region of the basic curve, relaxing the tension, and then redrawing to the breaking point. It will be noted that curve *c* resembles curve *a* in that it rises steeply and roughly linearly to a point above the

basic curve and then has a pronounced bend toward the basic curve. Considering the reduced cross section of the fiber, however, Young's modulus has now risen to a value of $(6 \pm 1) \times 10^5$ lbs./sq. in., while the elastic limit is about three times that of curve *a*. The x-ray diagram obtained at the point of relaxation (Figure 10C) exhibits short arcs, almost unresolved, and a ring about as strong as that in Figure 10A. The layer lines are slightly less curved than those of Figure 10A and more diffuse. On the whole, it appears that the more severe drawing (as compared with curve *a*) has led to smaller or less perfect regions of crystallization but to a higher degree of orientation.

(*d*) Finally, initial drawing to point *C* (Figure 7) was followed by relaxation of the tension, 24 hours of soaking in dilute phenol, reconditioning, and redrawing. The curve then obtained has been labeled *d* in Figure 7. It bears just about the same relationship to curve *c* as curve *b* does to curve *a*. Again, an x-ray diagram was obtained following the phenol treatment, shown in Figure 10D. Compared with Figure 10C, it shows better resolution, while the arcs are somewhat shorter than those of Figure 10B. As for the layer lines, the intensity appears to shift toward the end, apparently indicating the beginning of a development which culminates in a pattern of the kind shown in Figure 4. On the whole, of the four diagrams of Figures 10A–D, the last one indicates the highest degree of crystallization combined with the highest degree of orientation. At the same time, curve *d* appears to indicate the highest elastic limit of the four samples.

Summarizing this comparison, it appears that drawing produces orientation at the expense of crystalline perfection, which, however, can be restored without loss of orientation by suitable swelling. High orientation increases Young's modulus and the elastic limit, whereas improved crystal perfection increases at least the elastic limit; however, the degree of orientation apparently affects these mechanical parameters more strongly than crystal perfection. In any case, all curves have a tendency to approach again the basic curve upon prolonged redrawing.

This last statement implies a special application of the general principle that sufficiently drastic treatment tends to cancel out the effects of previous treatment, which is well known in metallurgy, although there are exceptions to this rule. An interesting illustration of this principle, which was obtained by accident, is shown in Figure 8. It represents curves of two specimens, following procedures (*b*) and (*d*) as indicated above. It happened that both fibers broke at the same elongation, 5.8 inches, outside the dye marks, and, without further soaking, they were redrawn a second time. The load-elongation curves of the two fibers coincided well within the limits of accuracy of the testing equipment; they are shown as curve *e* of Figure 8.

Figure 9 is reproduced as an example of reversible linear elongation. This specimen was drawn to the breaking point and, without intermediate soaking, was redrawn twice. The second break occurred after a definite bend, and the relaxed length showed that between the first and the second break there had been some further plastic deformation. After the third break, the fiber returned exactly to the length it was after the second break, and since the third curve is also linear, without any recognizable knee or bend, the third drawing obviously represents purely elastic deformation, in spite of the fact that the reversible elongation along it amounts to more than 25 percent of the length under zero load.

Acknowledgment

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Staining of Viscose Rayon Cross Sections*

P. H. Hermans†

Abstract

If short cuttings of viscose fibers are exposed to solutions of certain dyes like Solophenyl Fast Blue Green BL and Sky Blue FF it is seen that the skin resists penetration of the dye for a considerable length of time, whereas the dye diffuses readily into the core from the fiber end. This phenomenon, designated as "anisotropic diffusion," gives a ready explanation of the selective staining of the core in fiber sections by a number of dyes.

The penetration x of the dye into the core with time t has been measured for one dye and a number of fiber samples; it conforms to the equation $xt^{-\frac{1}{2}} = \text{constant}$. The speed of penetration varies over several orders of magnitude in the samples investigated, including ordinary tire cord and Lilienfeld rayons.

After a very long time at room temperature, and much faster if the temperature is raised sufficiently, the dye also penetrates into the skin. At equilibrium absorption both skin and core become stained; often, not always, depending on the dye used, the core remains stained to a darker shade than the skin when either sections or fibers are dyed.

Attention is drawn to the striking fact that Bordeaux Extra is an example of a dye which readily penetrates the skin, although it is also a tetrazo dye with almost the same molecular size as Sky Blue FF, which does not.

In sections dyed to equilibrium, the dye readily bleeds off the core on washing with water, whereas the skin remains stained. This provides an easy means to obtain selective staining of the skin with a number of dyes.

The Victoria Blue technique for selective skin dyeing disclosed by Morehead and Sisson is discussed and a much simplified modification of it is recommended.

The differential staining of viscose and cuprammonium rayon with dye mixtures such as Neocarmin W is explained by the absence of a skin in cuprammonium rayon. It is shown that Lilienfeld-process rayon also has a skin exhibiting similar properties towards dyes as ordinary viscose rayon.

THE different dyeing properties of skin and core in cross sections of viscose yarn are well known. In most factories dyeing experiments with yarn sections to determine these properties are routine procedure in production control. Very little is known with certainty about the actual nature of the skin-core differentiation, although various theories have been proposed [5, 7]. It is known that the skin has a higher degree of longitudinal orientation [7, 10] than the core and that its lateral orientation is also different [1]; furthermore, the skin exhibits a higher optical density and probably a lower degree of swelling in water [1, 5].

Morehead and Sisson [5] have contributed materially to our knowledge of the empirical conditions of the skin formation and have criticized earlier theories. In their own consideration particular emphasis was laid on the action of bivalent metal ions as zinc in the spinning bath. Although zinc ions doubtless have an important bearing on the thickness of the skin and the shape of the cross section, their presence is not necessarily decisive since typical skin formation may also occur in rayon spun in a bath free of bivalent ions [1]. Quite recently another important contribution has been published by Japanese authors [2], who studied cross sections of "freely coagulated" filaments with optical and electron microscopical methods. Their paper confirms the view that the skin has, on the average, a denser structure than the core. However, whether their "osmotic compression" theory can be maintained remains an open question. If the radial compression resulting in tangential orientation of the skin actually occurs, as they claim, the sign of the double refraction of the skin would be opposite to the sign actually found by us, as described in another paper [1].

It would seem that still more work is necessary before a satisfactory answer to this question can be obtained.

* Communication No. 51 from the Laboratory for Cellulose Research of the AKU and Affiliated Companies, Utrecht, Netherlands.

† Director of the Institute for Cellulose Research, Utrecht, Netherlands.

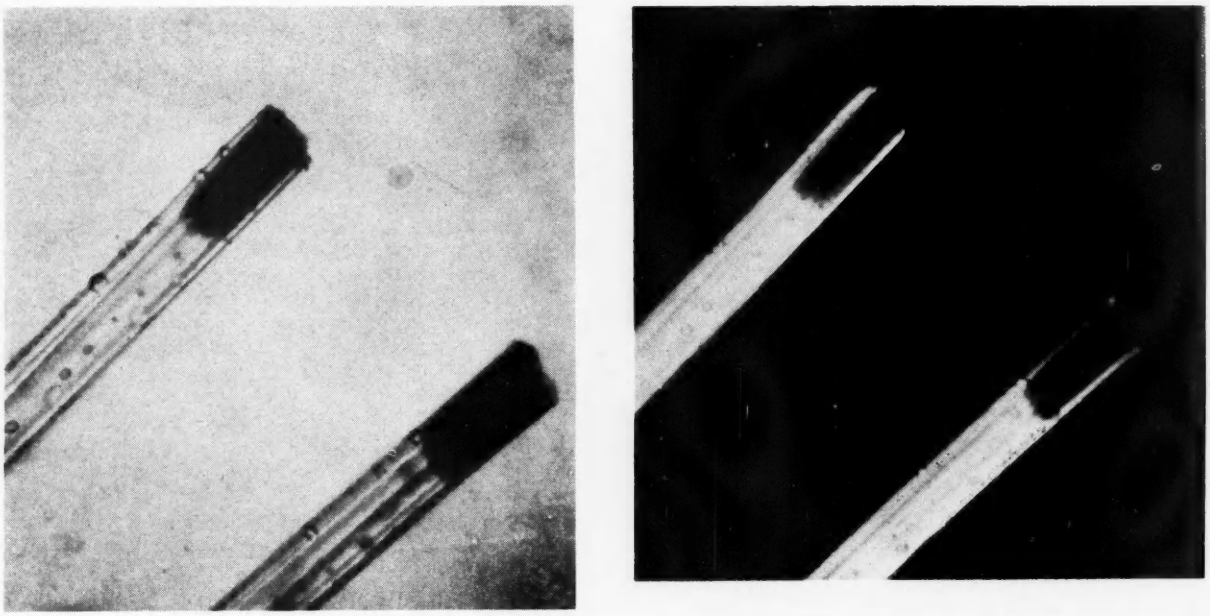


FIG. 1. *Cut elementary filaments of tire-cord rayon in 1-percent Solophenyl Fast Blue Green BL solution. A (left)—In ordinary light. B (right)—Between crossed nicols.*

In this paper it is not the intention to discuss either the nature of the skin-core effect or that of its origin, but merely to consider how it affects dyeing phenomena. Simple methods for obtaining selective dyeing of the skin are offered.

Dyeing experiments with cross sections have been published by various authors [3, 6, 7, 8, 9, 10] but no consistent survey of the phenomena has thus far been given. A method for selective skin dyeing was recently published by Morehead and Sisson [5]. However, this method is rather complicated and involves the liberal use of the highly poisonous and dangerous solvent dioxan. These authors have also contributed materially to our knowledge of the empirical conditions influencing the thickness of the skin.

The Phenomenon of Anisotropic Diffusion

The phenomenon which we shall designate as "anisotropic diffusion" (AD)—although this terminology is not strictly adequate—can be observed if short, cut lengths of elementary filaments are immersed in solutions of certain dyes and examined under the microscope. Figure 1 shows cut tire-cord rayon fibers (having a relatively thick skin) when exposed to a 1-percent solution of Solophenyl Fast Blue Green BL (Geigy), in ordinary light and between crossed nicols. It is seen that the dye diffuses into the core of the filaments, leaving the skin unaffected. The fibers should preferably be cut by moving them along a sharp razor blade. If they are cut with scissors, squeezing of the ends tends to occur, and this may retard the diffusion of the dye (see Figure 2). This phenomenon of AD can be observed in almost any viscose rayon but the speed of penetration may vary over a range of several orders of magnitude, depending upon the sample

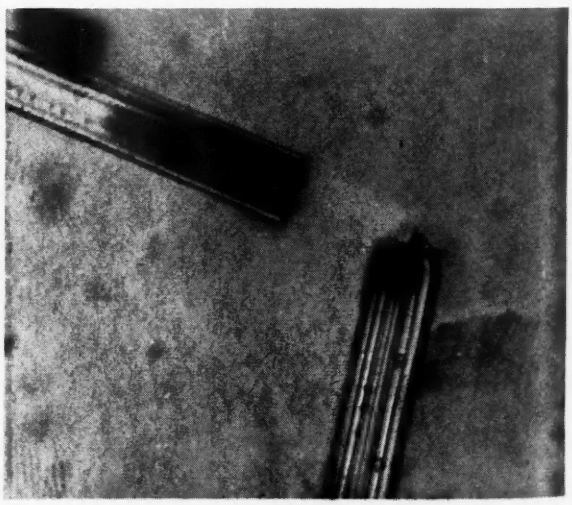


FIG. 2. *Two ends of the same fiber, one cut with a razor, the other with a pair of scissors; both exposed to the dye solution for the same length of time.*

TABLE I. THREE EXAMPLES OF DETERMINATION OF THE AD CONSTANT FOR 1-PERCENT SOLOPHENYL FAST BLUE GREEN BL IN RAYON SAMPLES (ROOM TEMPERATURE)

							k (average) (microns/day^{-1})
Ordinary viscose yarn (Dutch Enka)							
Time (days)	7	8	9	38			
Penetration in μ	72	73	85	160			
$k = xt^{-\frac{1}{2}}$	24	25	28	26			26
Tire yarn (Industrial Rayon Corp.)							
Time (days)	0.176	0.25	1.08	1.25	2.04		
Penetration in μ	37	65[5]	82	111	132		
$k = xt^{-\frac{1}{2}}$	90	130	80	99	93		98
Experimental tire yarn							
Time (days)	0.0069	0.0207	0.0345	0.0832	0.25	2.00	
Penetration in μ	48	64	93	121	260	800	
$k = xt^{-\frac{1}{2}}$	570	435	500	420	520	565	500

used. It also depends primarily on the dye employed. Measurements of the average length of penetration x in 10–20 fibers against time t show that the quantity $xt^{-\frac{1}{2}}$ is a constant, as would be expected for a diffusion process. This constant may be used to characterize a rayon specimen, if a given dye solution is used. Table I shows three examples of the determination of the diffusion constant k expressed in microns/day^{-1}.* In Table II a more extended list of constants is given, and, in the last column, the time in hours required for penetration of 100 μ is indicated. The latter figures illustrate particularly the huge differences between various rayon specimens, which amount to over four orders of magnitude.

The permeability of the core to dye shows very large variations from sample to sample. The phenomenon would, however, not exist in this form if there were not a still larger difference in permeability between core and skin. The latter acts as a protective membrane which is practically impermeable to the dye at room temperature.

After prolonged immersion the skin also stains very slowly; however, in experiments similar to the 38-day experiment listed in Table I, the intensity is so low that it permits distinct reading of the boundary of the dye dispersing into the core.

When the temperature is raised the difference in permeability between skin and core becomes rapidly smaller, indicating that potential barriers seem to be involved in the process of penetration.

When other dyes are used the phenomena may change entirely from the quantitative point of view. For instance, in some of the samples listed in Table II the dye Congo Rubine (C.I. 376) diffuses into the core more slowly, and in others more rapidly, than does Solophenyl Fast Blue Green BL, although the differences are not very significant. On the other hand, the differences in permeability between skin and core are much smaller for this dye. This is borne out by the fact that even after an interval of ½ to 24 hours (depending upon the sample investigated) the skin becomes so intensely stained that

TABLE II. LIST OF AD CONSTANTS k AND OF THE TIME $t_{100\mu}$ (IN HOURS) REQUIRED FOR 100-MICRON PENETRATION (ROOM TEMPERATURE)

Specimen	k	$t_{100\mu}$ (hours)
1. Yarn spun from low-alkali viscose in zinc-free bath	10	2,400
2. Yarn spun from high-alkali viscose in zinc-free bath	10	2,400
3. Cantona (commercial AKU yarn)	10.6	2,150
4. Briglo R (commercial American Enka yarn)	19.5	
Experimental yarns spun from ordinary viscose in ordinary bath containing zinc		
5. 10% stretch (one-bath system)	26	350
6. 50% stretch (two-bath system)	27	330
7. 80% stretch (two-bath system)	53	85
8. Sedura (a Lilienfeld-type product)	40	150
Commercial tire-cord rayons		
9. Cordura (Du Pont Rayon Corp.)	~45*	
10. Tempra (American Enka)	150	10
11. Cordenka (Enka, Netherlands)	~150*	10
12. Rayflex (American Viscose)	316	2.4
13. Experimental tire-cord yarn	495	0.9

* Some elementary filaments were slow-staining, depressing the average.

* It has been found in the meantime that in some commercial yarns the different single filaments of one thread may show considerable variations in speed of AD. In such cases the determination of k becomes rather uncertain and the averaged $xt^{-\frac{1}{2}}$ may not remain constant with time.

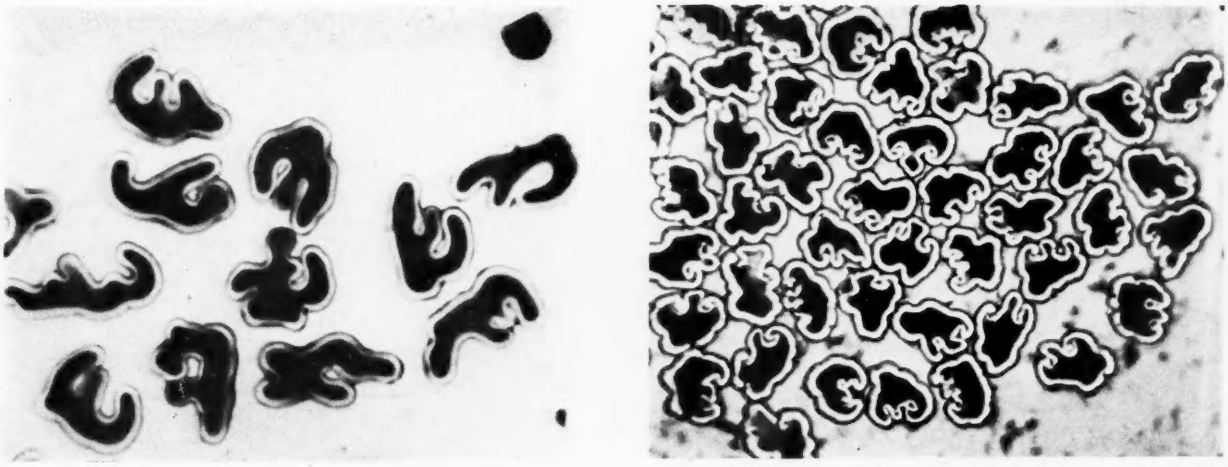


FIG. 3. *Rayon cross sections with stained core. A (left)—Ordinary viscose yarn stained with Sky Blue FF. B (right)—Tire-cord yarn stained with Solophenyl Fast Blue Green BL.*

observation of the boundary proceeding into the core is no longer possible.

Rapid staining of the skin is still more pronounced with Bordeaux Extra (C.I. 385). All three of the dyes mentioned are tetrazo dyes with about the same molecular weight, making any explanation of the phenomenon the subject of some rather embarrassing questions. The explanation, however, is not our concern here, for we wish only to suggest the practical applicability of this technique for the characterization of yarn samples and dyes and to direct attention to the significance of these phenomena for the study of rayon dyeing.

Selective Staining of the Core

There are numerous dyes which will stain the core of viscose yarn cross sections but leave the skin more or less unaffected. It will be clear from the foregoing that this is due to the phenomenon designated as AD. Since even slight penetration of dyes into the core will show up in the cross section as differential staining, the large differences in velocity of penetration of the dyes into the core which exist between various yarn samples are less readily detected when sections are stained. For a dye like Solophenyl Fast Blue Green BL, however, differences of speed of core staining can be observed, in that satisfactory core staining for some samples is a matter of seconds; for others, a matter of several minutes. Another suitable dye for selective core staining is Sky Blue FF (C.I. 518). Congo Rubine can also be used if the staining is not continued over too long a period; but Bordeaux Extra cannot be used for this purpose since the skin as well as the core is stained very quickly. The suitability of a dye for selective staining can, of course, easily be tested with the aid of simple AD experiments of the kind illustrated in Figure 1.

Figure 3 shows two examples of sections with a selectively stained core. In Figure 3A the dye employed was Sky Blue FF, and in Figure 3B, Solophenyl Fast Blue Green BL.

Dye Absorption Approaching Equilibrium

The phenomena of differential staining discussed so far have their origin in differences in velocity of diffusion. It seemed also of interest to study the situation at sorption equilibrium.

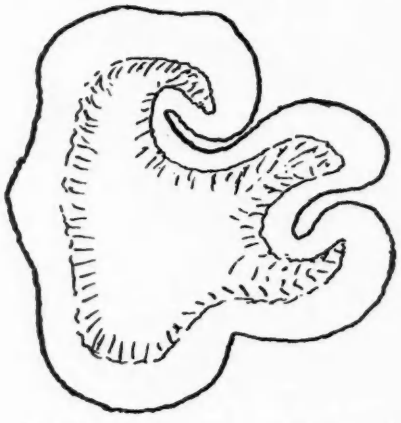


FIG. 4. *Sketch of appearance of the sections of a tire-cord yarn dyed in yarn form for ½ hour at 80° C in 1-percent Solophenyl Fast Blue Green BL + 2-percent NaCl.*

To that end, cross sections mounted in the usual way with egg albumin on slides, or yarn samples, were dyed for long periods at higher temperatures, with and without addition of salt to the dye bath, using various dyes. The sections were examined at intervals, and so were the yarns after sectioning a sample. The details of these experiments will not be given here—only the outcome.

The usual result was that at equilibrium both skin and core became stained, but almost invariably the core was more intensively stained than the skin. Some dyes, however, attain almost equal absorption in skin and core. In order that one may see exactly what happens during staining, the dyed sections mounted on slides should not be washed when they come from the dye bath but should be allowed merely to drip, then be wiped with filter paper, except for the spot where the sections are mounted, and dried on a hot plate. Sections of samples dyed in yarn form should likewise be examined without being brought into contact with water.

After half an hour of dyeing at 80°C in a solution of 1-percent Solophenyl Fast Blue Green BL to which 2 percent of sodium chloride had been added, the samples listed in Table II showed that the dye had just penetrated the skin and was beginning to extend into the core. In the section, the intensity of the color was seen to rise suddenly at the boundary between skin and core and to fade away toward the center of the sections where the dye had not yet entirely penetrated (see Figure 4). The skin was then only faintly stained.

After prolonged dyeing the staining of both skin and core increased. Finally the entire core exhibited a darker shade than the skin and remained so, even after dyeing for 1 week at 80°C. This was the case with the majority of the dyes tested.

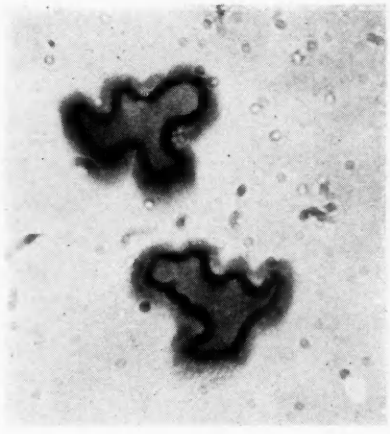


FIG. 5. *Partially washed-out sections of a tire-cord yarn previously dyed to equilibrium (mounted in n = 1.520).*

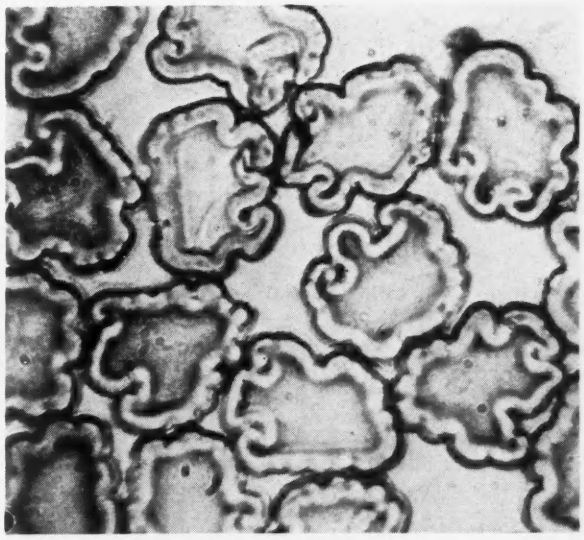


FIG. 6. *Partially washed-out sections of a tire-cord yarn previously dyed to equilibrium (mounted in n = 1.444).*

If the dyed sections or the sections of dyed yarn were washed with water, the stain was seen to bleed rapidly off the core but to remain in the skin. This was observed with all of the three dyes tested—Solophenyl Fast Blue Green BL, Sky Blue FF, and Congo Rubine. The discoloring of the core could always be accomplished with distilled water within a few minutes in so far as sections of samples dyed in yarn form were concerned. In dyed sections the stain was sometimes slow in bleeding off the core in distilled water but did so readily after addition of 5 percent pyridine to the latter. This difference may have been due to traces of impurities which contaminated the surface of the dyed sections.

In tire-cord yarns it was repeatedly observed that during washing a narrow zone of the core next to the skin discolored much later than the central part and then showed up as a dark line. Figure 5 is a micrograph of such partly washed-out sections after drying and immersion in a liquid of the same refractive index. (Owing to the absence of diffraction effects, the outer circumference of the skin is marked through light absorption only.)

Another case, in which washing has been carried a little farther, is shown in Figure 6. The dark line is less pronounced here but sufficiently distinct to accentuate nicely the boundary between skin and core. Since a green dye was used and no color filter was

FIG. 7. *Washed-out sections of a tire-cord yarn previously dyed with Solophenyl Fast Blue Green BL, photographed with a contrasting light filter (mounted in $n = 1.515$).*

applied in taking the picture, the staining of the skin cannot be detected in the photograph. The sections in Figure 6 were mounted in a liquid of lower refractivity ($n = 1.444$).

Figure 7 shows similar sections washed until complete disappearance of the dye from the core occurred and photographed with a contrasting light filter.

By laying fiber fragments cut from previously dyed yarn in water or very dilute pyridine, reversal of the phenomenon illustrated in Figure 1 can be demonstrated. One sees the dye rapidly bleeding off the cut ends, whereas no detectable amounts are observed to pass the skin (Figure 8). In Figure 9 a partially bled-out fiber end is shown enlarged, photographed in polarized light. These phenomena seem to throw an interesting light on the water-fastness of dyes in rayon.

Selective Staining of the Skin

It is clear that nice selective skin staining with a number of dyes can be based on these phenomena.

For routine purposes one has but to select a suitable combination of dye and color filter. Solophenyl Fast Blue Green BL and Sky Blue FF give good results in combination with a yellow filter, selectively transmitting the spectral region next to the sodium lines. The sections should be dyed at a high temperature and with the addition of salt in order to get as much stain on the skin as possible. With the dyes

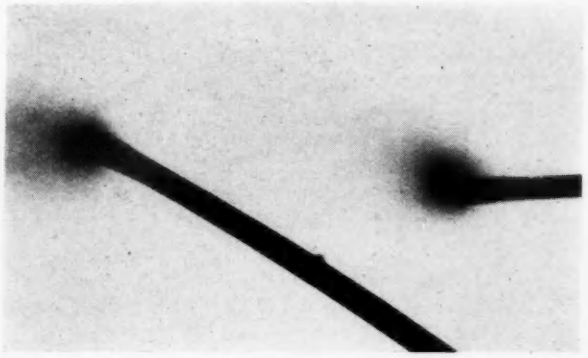


FIG. 8. *Dye bleeding off the cut ends of previously dyed fibers.*

mentioned, staining for 5 hours at 70–80°C yields satisfactory results. Washing should be done with a very dilute pyridine solution.

In 1945 Morehead and Sisson [5] reported a method for selective staining of the skin using Victoria Blue (C.I. 729) (a basic diphenylnaphthyl dye). This dye diffuses rapidly into both skin and core, even at room temperature, and on washing with water also bleeds off readily from both skin and core. For samples of rayon for which k is large, as in specimen no. 13, Table II, the phenomenon of AD can be observed for only a very short time, as the staining of the skin inhibits further observation.

Whereas the staining with dyes like Sky Blue FF is fast to the skin and not to the core, so that a simple water wash can be applied for selective skin staining, Victoria Blue is neither fast to the core nor to the skin, so that some other procedure must be followed to obtain selective skin dyeing. That recommended by Morehead and Sisson comprises the following steps:

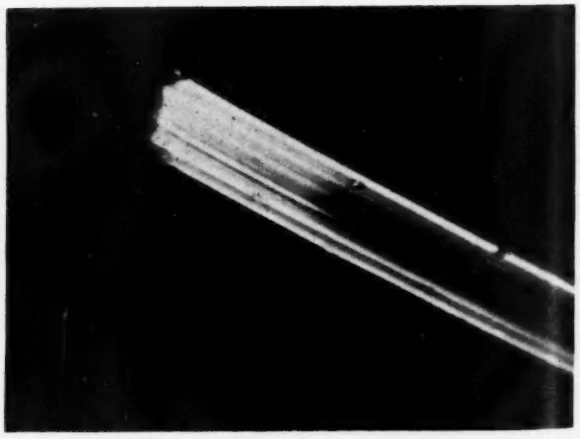
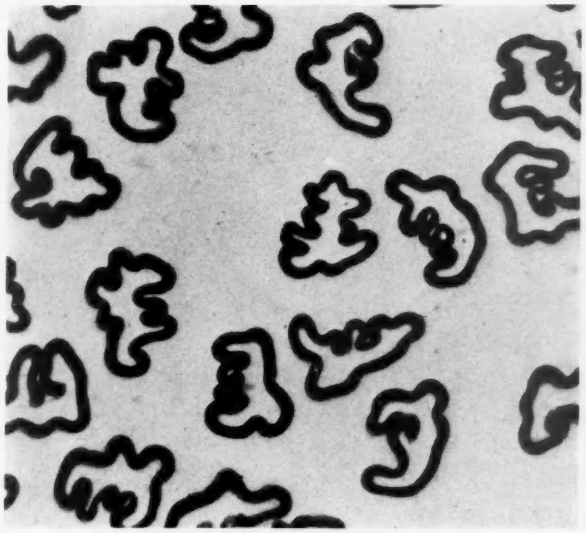


FIG. 9. *Enlarged photograph of bled-out core in fiber end (between crossed nicols).*



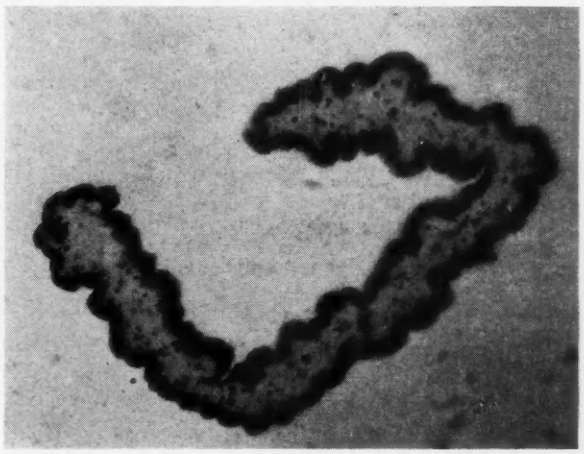


FIG. 10 (*left and above*)—*Examples of skin staining with Victoria Blue.*

The dewaxed sections are successively placed in 95-percent, 60-percent, and 30-percent ethyl alcohol (by volume) and stained in 2-percent Victoria Blue solution for 1–2 hours. The slide is rinsed with distilled water, allowed to drain, and the water is wiped from the back. Then the slide is washed first for 5 seconds in 100-percent dioxan, then washed 4 times for 5 seconds in 90-percent dioxan, and dried.

We believe that the essential element in the above procedure is the washing with the dioxan-water mixture, thus using water with "lowered activity."

The sections which remain unswollen in 100-percent dioxan do swell in 90-percent dioxan. As Morehead and Sisson indicate, the dioxan concentration is critical. On further addition of water to the dioxan, the dye begins to bleed off the skin. We have found that successive treatments with 100-percent pyridine and a mixture of 6 ml. pyridine with 1 ml. water ($n_D^{25} = 1.485$) yields the same result. Also in this mixture the sections just begin to swell.*

In using Victoria Blue, a much simpler procedure, which avoids the use of dioxan, can be followed. This has given even better satisfaction and more definite results and can be recommended for routine tests. Steps in this procedure are:

1. Sections mounted on slides are stained in a 2-percent solution of Victoria Blue at room temperature for at least 1 hour (or longer, if convenient).

2. The slides are taken out of the dye bath, allowed to drain, wiped with filter paper to remove adhering dye solution except for the spot where the sections are mounted, and then allowed to dry on a hot plate (at about 90°C).

3. The slides are rinsed with alcohol of 96-percent by volume. This removes the remaining dye adhering to the glass, leaving the sections unaffected. Both skin and core are now stained blue, the latter, however, distinctly heavier than the former.

4. The sections are washed for about 3–6 minutes with alcohol of 89-percent by volume (density 0.837 at 15°C) either under the cover glass during examination under the microscope or in a trough. The core then rapidly gives off the dye, whereas the skin remains stained.†

5. The sections are rinsed with 96-percent alcohol to stop further effects of the washing and finally dried on a hot plate. They are now ready for mounting in a nonaqueous medium for examination.

The dilution of the alcohol is not very critical; it can, in fact, be slightly more dilute. At a strength of 80-percent by volume, however, it is observed that after a period of 5 minutes the skin has also started to bleed.

Victoria Blue has an advantage over the direct dyes referred to in that it is nondichroic. This is useful when sections are examined in polarized light

* When examining the degree of swelling in pyridine with increasing water content, it is found that considerable swelling sets in suddenly when a certain dilution is reached. This critical degree of dilution closely corresponds to that required for selectively removing the dye from the core.

† The time of 3–6 minutes indicated for the washing operation holds for the majority of commercial yarns but may vary according to the particular yarn under investigation. For experimental yarns it has sometimes been necessary to wash as long as 15 minutes. There is a negative correlation between the length of this washing time and the constant of anisotropic diffusion referred to above.

because the lateral components of orientation [1] can be observed. In white light most dyes give rise to complicated color phenomena which are not easy to analyze because they are very sensitive to the amount of color absorbed. Micrographs of cross sections treated according to this procedure are reproduced in Figure 10. One is from a yarn spun from a slit orifice.

Even in particularly difficult cases in which the technique of Morehead and Sisson tended to give a negative or doubtful result, good results could be obtained by this method. An example is given in Figure 11. This shows a fiber which was spun in a concentrated ammonium sulfate bath containing 8-percent sulfuric acid. Anisotropic diffusion is extremely slow in this fiber and it has only a very thin skin which is difficult to detect. The picture, taken with a contrasting yellow filter and the sections mounted in a medium of almost equal refractivity (so that contours would be hardly visible if no stained skin were present), shows that there actually seems to be an extremely thin skin.

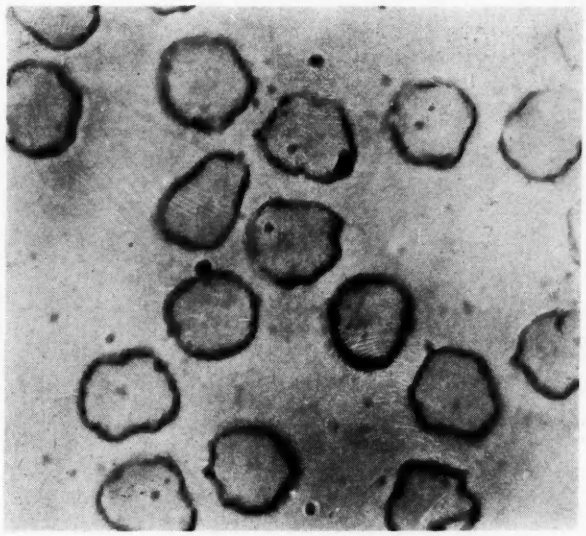


FIG. 11. *Extremely thin skin in an experimental fiber detected with the Victoria Blue-alcohol technique.*

Comparison of Viscose and Cuprammonium Rayon

In the literature several staining reagents are recommended for distinguishing viscose from cuprammonium rayon. A well-known commercial reagent of this kind is Neocarmin W[4]. It consists of a mixture of several dyes in aqueous solution. It stains viscose rayon a light violet and cuprammonium rayon a dark blue shade. The explanation of this rather curious fact becomes clear if AD experiments of the kind shown in Figure 1 are carried out with Neocarmin solution. Using cuttings of viscose filaments, it is seen that the surface of the fiber is actually stained grayish violet, whereas a blue dye penetrates into the core from the fiber end. Obviously, the skin is impermeable to the blue component of the reagent, but permeable to other components, giving rise to the violet coloring of the entire filament.

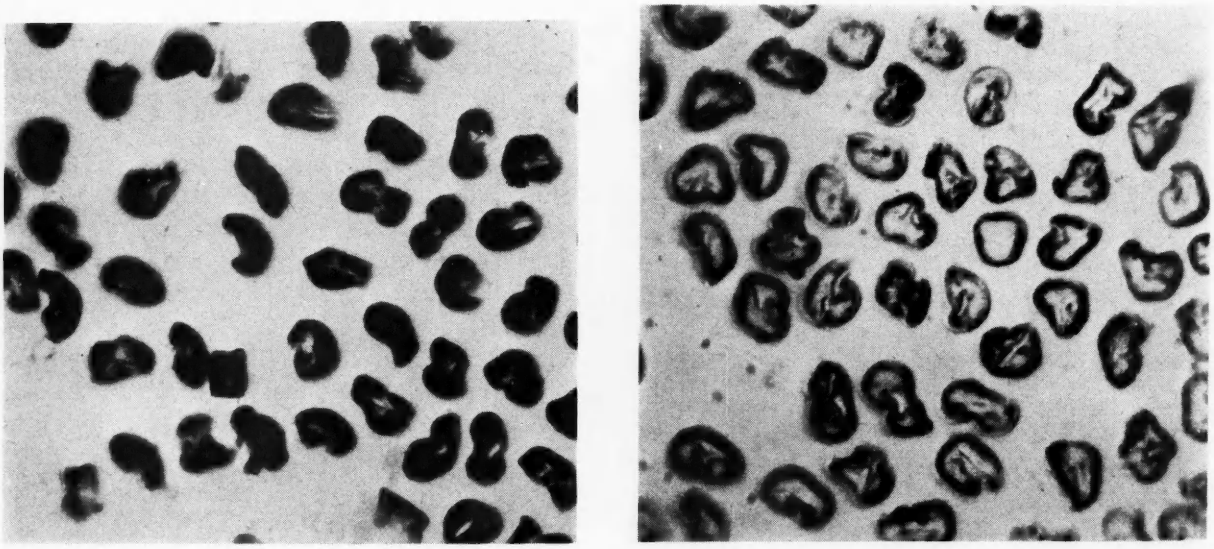


FIG. 12. *Lilienfeld yarn sections dyed with Victoria Blue. A (left)—Before, and B (right)—after, treatment with 89-percent alcohol, photographed with yellow light (mounted in n = 1.494).*

Cuprammonium fibers readily stain blue over their entire surface. Because no skin is present in this case, the blue dye can penetrate freely from the periphery of the fiber.

In our experiments we were struck by the fact that viscose rayon spun according to the Lilienfeld process in concentrated sulfuric acid also stains to the same violet shade as common viscose rayon when treated with Neocarmin W. This seemed to indicate that, contrary to the usual statements in the literature (recently confirmed by Morehead and Sisson [5]) that Lilienfeld rayon belongs to the skinless types of fiber, it actually must have a skin with permeability to dyes similar to that of ordinary viscose fibers. Moreover, Lillienfeld fibers also show the AD phenomenon (*cf.* Table II). The presence of a skin was corroborated by the Victoria Blue-alcohol technique. Figure 12 shows Lilienfeld yarn sections after dyeing in Victoria Blue before and after application of 89-percent alcohol. The presence of a skin is clearly demonstrated. It should be remarked, however, that in this case the treatment with alcohol of 89-percent strength had to be prolonged for a markedly longer period compared to that required for common viscose yarns in order to obtain this effect. It would also seem that the sharpness of the boundary between skin and core may be somewhat less pronounced in Lilienfeld fibers.

Discussion

The phenomena dealt with in this paper tend to confirm the fact that in viscose fibers swollen in water the skin has a denser structure than the core, as demonstrated by the marked difference in permeability and in equilibrium absorption of a number of dyes. This observation also conforms qualitatively with optical investigations on refractivity [1] and with the recent contribution of Horio *et al.* [2]. The tremendous differences in diffusion velocity of a given dye into the fiber core, which were shown to exist in various rayons, demonstrate moreover that the permeability and, consequently, the fine structure of the core itself may also vary within wide limits according to the conditions of manufacture. Whether or not similar variations in the permeability of the skin occur remains to be disclosed. It would seem that the diffusion velocity of dyes is particularly sensitive to even slight variations in those conditions. This is in conformity with well-known practical experiences in rayon dyeing.

It would seem that a number of important new problems inviting further investigation arise from the facts here disclosed which may be of interest to the rayon manufacturer, especially to the dyer, as well as to the scientist.

Acknowledgment

The author is indebted to the N. V. Onderzoekingsinstituut Research, Arnhem (Netherlands), and to the American Enka Corporation, Enka, N. C., for providing rayon and dye samples.

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Inter-Society Color Council to Meet

THE 17th Annual Meeting of the Inter-Society Color Council will be held in New York March 2–3, 1948, at the Hotel Pennsylvania. All who are interested will be welcome to attend. Copies of the final program may be obtained by writing to the Chairman of the Program Committee, Walter C. Granville, Container Corporation of America, 38 S. Dearborn St., Chicago 3, Ill.

Textile Testing in Germany*

Part II. Serviceability Evaluation of Textiles

Herbert F. Schiefer, Lyman Fourt, and Richard T. Kropf

1. General

The evaluation of the serviceability of textile fibers, yarns, fabrics, and garments is important to the producer and the consumer of textiles. The different aspects of the measurement of resistance to wear and the evaluation of serviceability have received considerable attention in recent years in the United States, England, and Germany. This work has resulted in the development of numerous wear-testing instruments. The research of the textile technologists of Germany on the evaluation of the relative serviceability of textile fibers was intensified during the war in an endeavor to obtain the optimum amount of wear from the available textile products. Many of the German textile products contained a high percentage of rayon staple fiber and some were made entirely from staple rayon. In this endeavor a number of special tests were devised to evaluate the staple fiber, the yarn, and the finished fabric in the laboratory. One object was to combine the measured values of several properties of the fibers, yarns, and fabrics into a single wear index that could be used as a measure of the performance of the product in service. Such an index provides a laboratory tool for evaluating systematically the effect of fiber composition and yarn construction in an effort to find the optimum composition and construction to yield the best performance or the maximum serviceability.

The philosophy of combining the measured values of a number of properties into a single numerical value or index is not new. However, the German textile technologists have arrived at several concrete solutions and it may be well to review their work to stimulate thought and provoke discussion. Since the economic conditions in Germany and the kind and supply of fibers were different from those in the United States, the numerical values presented probably have little meaning as such and should be regarded as illustrative only. The systematic and thorough planning of the experiments and the patience to carry them out according to plan could well serve as a guide in future research. It is unfortunate that complete information concerning the results of the actual service tests was not available for all of the planned researches to permit correlation with the laboratory test results obtained on the fibers, yarns, and fabrics. The information which is presented in this report is based upon the researches directed by Albert von Oestermann, Manager of Schachenmayr, Man & Cie at Salach; Richard Gütermann, Manager of Gütermann, A. G., at Gutach; Prof. F. Walz, Director of the German Research Institute for Textile Industry at Reutlingen; Dr. H. Böhringer of the Textile Research Laboratories of the ZKR (Zellwolle- und Kunstseide-Ringes, G. m. b. H.) at Schwarza; R. Stoll of the Research Institute of the Southern German Staple Rayon Company at Kelheim; K. Ramsthaler of the Textile Laboratories of the Saxony Staple Rayon Company at Plauen; and Dr. E. Wagner of the Official Testing Laboratory for Textiles at Wuppertal. The instruments used in Germany for testing the resistance to abrasion are described. A bibliography of the more important papers on wear and evaluation of serviceability of textiles is given.

2. Research on Knitted Fabrics by Schachenmayr, Man & Cie

The performance tests directed by Oestermann were made on men's socks. The socks were knitted without any reinforcing. One sock of each pair was made from standard wool yarn and the other from the experimental yarn to be evaluated for effect of kind of fibers, fiber blend, or yarn construction. The experimental sock was made structurally as nearly like the wool sock as possible. A pair of the socks

* Part I of this report appeared in the December, 1947, issue, page 689. Parts III and IV will appear in the February issue. Reprints of the entire report, bound in serviceable covers, will be available following completion of publication in that issue, *provided a sufficient number of advance orders are received to justify the printing.* Orders should be sent immediately to Textile Research Institute, 10 E. 40th Street, New York 16, N. Y. Price, $3.50 a copy, postpaid.

TABLE VI. APPROXIMATE RESULTS OF SERVICE WEAR TESTS ON MEN'S SOCKS

	Days	Percent
Nylon	60	300
Wool	20	100
Cotton	20	100
Cupra staple	8	40
Viscose staple	7	35
Acetate staple	3	15
Casein staple	1	5

was worn by a man, who wore each one alternately on the left and the right foot. No other specifications were prescribed for the performance tests; the frequency of laundering and the method of laundering were left to the discretion of the wearer. The length of service which was obtained from each sock of a pair was recorded. The comparative wear was based upon the results of tests of ten pairs of socks which were worn by ten different men. For each pair a value of 100 was assigned to the wool sock and the result for the experimental sock was expressed as a percentage of the value for the wool sock. This procedure eliminated the large fluctuations from the data and the average of ten pairs was said to give an adequate evaluation of an experimental type of sock. The approximate results of service wear tests on men's socks made from different fibers are given in Table VI. Nylon was found to be about three times as durable as wool, whereas viscose rayon, acetate rayon, and casein were about $\frac{1}{3}$, $\frac{1}{7}$, and $\frac{1}{20}$ as durable as wool, respectively. Cotton was about as durable as wool.

Although it would appear that performance tests yield the best answer with respect to relative wear for men's socks, they were not satisfactory and practical for making the systematic investigations for determining the optimum fiber blend and yarn construction for maximum performance. For such a study, quicker and more closely controlled methods were needed. Accordingly, a technique was developed for obtaining a wear index which was based upon combining the results of a number of laboratory tests of the yarn and knitted fabric. The properties which were measured are given in Table VII. These tests include the following: breaking strength of the yarn tested dry; breaking strength of the yarn tested wet; ratio of wet to dry strength of the yarn; yarn flexing, which is given a weight of 2 because of its greater importance; abrasion of yarn against yarn tested wet; abrasion of yarn against yarn tested dry; abrasion of knitted fabric tested dry; abrasion of knitted fabric after boiling in soap solution, well rinsed, and tested dry; and swelling value. In order to illustrate the manner of arriving at the wear index from these measurements, assumed numerical values are given in column 2 of Table VII. The highest values ever attained for each property measured, and also assumed values for purpose of illustration, are given in column 3. The value of a property given in column 2 expressed as a percent of the value in column 3 is given in column 4. The swelling value is taken equal to 108 minus the amount of water retained by the test sample after a specific soaking and extraction procedure, where 108 is the highest amount of water ever retained. In this procedure a 10-gram air-dried sample is soaked in distilled water at 20°C for 30 minutes and the excess water is then removed by centrifuging for 1 minute at a centrifugal acceleration of 750,000 cm./sec.^{2} The sample is then weighed and again after drying to constant weight at 105° to 110°C. The difference between the water retained and the maximum value of 108 is taken, as a matter of convenience, equal to the swelling value since it is approximately the same as it would be if the difference were expressed as a percent of 108. The values of s of column 4 for the different properties may be combined since all are expressed in percent. The average of the values in column 4 minus 20 is the wear index of the material tested. This was derived, partly by intuition and partly by trial and error, so that it would correlate directly with the results of the actual service tests. The functional relationship between service and laboratory results is given by the equation $L = 13/4\ S + 20$, where L is the average of the laboratory values as computed in column 4 of Table VII and S is the length of service wear in days for socks knit from a specific fiber and yarn construction. The fit to the experimental data is shown in Figure 30. The significance of the constant 20 is a minimum value of L which the sock would still possess when it is discarded in service. Nylon is not shown in the figure because the relationship was established before nylon was available. The graph corrected for the constant of 20 (dotted curve in Figure 30) passes through the origin. The approximate relative laboratory wear indices for the different fibers are given in Table VIII. The percentages based upon the corrected values are given in the last column of Table VIII and are plotted against the values based upon the service tests in Figure 31. It will be seen that nylon

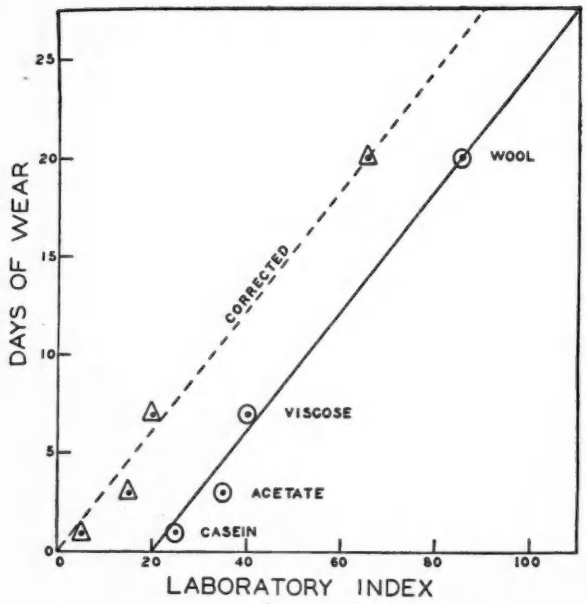


FIG. 30. *Relation between laboratory index and days of service wear of men's socks made from different fibers.*

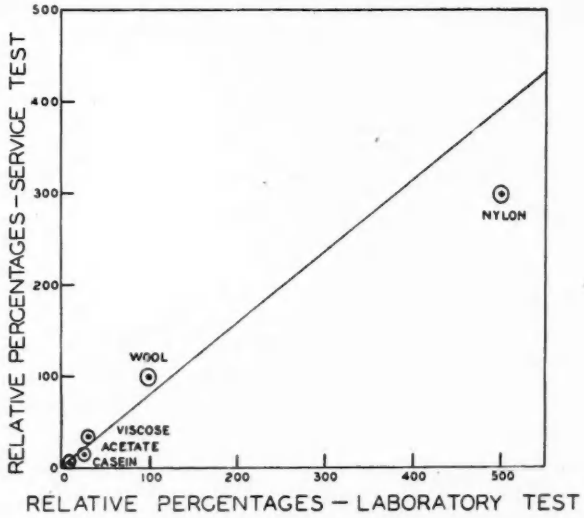


FIG. 31. *Relation between relative wear of men's socks, based upon laboratory and service tests and using the value of wool socks as 100 percent.*

does not depart too greatly from the curve which was deduced for the other fibers.

The technique of laboratory evaluation of a wear index was then employed to make systematic studies of the effect of such factors as ply, yarn size, twist, blend of fibers, and denier of rayon in blends. These systematic studies enabled Oestermann to make predictions regarding the optimum fiber blend and yarn construction which would yield fabrics giving the maximum performance. The optimum blend for socks included nylon for long wear, wool for comfort, and acetate to reduce felting shrinkage. The specific details used in this study in Germany are considered to be unimportant, for they probably would not be representative of the conditions prevailing in the United States. However, the general philosophy of this evaluation technique is important and its use may be of value in future research and in the evaluation of serviceability. A somewhat similar application of

TABLE VII. CALCULATION OF WEAR INDEX

Property measured	Value of test	Highest value	$\frac{\text{Value of test}}{\text{Highest value}} \times 100$ (%)
Breaking strength of yarn, dry	2000	2000	100
Breaking strength of yarn, wet	1000	1500	66
Ratio of wet to dry yarn strength	50	—	50
Yarn flexing	2000	6000	33
Yarn flexing	2000	6000	33
Abrasion of yarn against yarn, wet	90	180	50
Abrasion of yarn against yarn, dry	70	210	33
Abrasion of knitted fabric, dry	400	600	66
Abrasion of knitted fabric after boiling in soap solution, well rinsed, and tested dry	300	600	50
Swelling value *	28	—	28
	Average		51
			−20
	Wear index		31

* The swelling value is taken equal to 108 minus the amount of water retained by the test sample after a specific soaking and extraction procedure, where 108 is the highest amount of water ever retained. The difference is taken as a matter of convenience since its value is approximately the same as if the difference were expressed as a percent of 108.

TABLE IX. CALCULATION OF INDEX NUMBER FOR SEWING THREAD

Property measured	Value of test	Base value	Value of test * / Base value	Weight factor (%)	Weighted ratio (%)
Breaking length, dry, km.	35	42	0.83	25	21
Breaking length, wet, km.	24	32	0.75	10	8
Simple knot breaking length, km.	22	33	0.67	5	4
Elongation at break, %	24	22	1.00	10	10
Elastic recovery when loaded to 80% of breaking load, %	8	10	0.80	25	20
Friction number, g.	50	40	1.00	15	15
Flexing endurance, flexes	2500	3000	0.83	10	8
				Index number	86

* If ratio exceeds unity a value of 1 is used.

this technique has been developed independently for sewing threads by Gütermann.

3. Research on Sewing Thread by Gütermann, A. G.

The research department of Gütermann, A. G., has developed a method for evaluating sewing threads made of different fibers which is based upon the results of tests of seven different properties listed in Table IX. These tests included the following: breaking length of thread tested dry; breaking length of thread tested wet; breaking length of thread tested dry, with a simple knot tied in the specimen; elongation of the thread to the point of rupture; elastic recovery of elongation of thread loaded to 80 percent of the breaking load; friction number of the surface of the thread; and flexing endurance. In order to illustrate the technique of computing the index number of sewing thread, assumed values are given for these properties in column 2 of Table IX. The base values are given in column 3. They are based upon long experience of this organization with sewing thread giving satisfactory performance. The test value of a property, expressed as a ratio to its base value, is given in column 4. Unity is used if the ratio is greater than 1. The weight factor in percent for each ratio is given in column 5 and the product of a ratio by its weight factor is given in the last column. The index number is the sum of the seven values given in the last column.

The index numbers of sewing thread made from different fibers are given in Table X. A value of 75 percent was arbitrarily selected as the "percent acceptance." All values above this percentage are considered desirable; all values below are considered undesirable. It will be noted that silk and nylon sewing threads have the highest index number and spun silk just passes the acceptance limit.

This technique is the usual approach to this type of problem employed in the sewing-thread industry. The question of the correct weighting for each property still remains unanswered, and, it is believed, will remain unanswered for a general solution or index, in view of the fact that no one weighting for all properties produces the optimum for a multitude of varying sewing-thread requirements. Hence, a system of this type could be employed if a different set of weightings for each property were employed for each specific thread requirement. The employment

TABLE VIII. APPROXIMATE RELATIVE LABORATORY WEAR INDICES

	Wear index	Percent	Corrected wear index	Percent
Nylon	350	400	330	500
Wool	85	100	65	100
Viscose	40	50	20	30
Acetate	35	40	15	25
Casein	25	30	5	8

TABLE X. INDEX NUMBER OF DIFFERENT SEWING THREADS

Fiber	Index number * (%)
Pure silk	90
Nylon	86–89
Spun silk	75
Cotton	57
Spun rayon	48
Viscose rayon	44
Bemberg rayon	34
Acetate	33

* Index numbers greater than 75% are desirable and below 75% undesirable.

TABLE XI. INDEX NUMBER OF DIFFERENT SEWING THREADS

Physical property	Egyptian cotton	Russian cotton	Mercerized cotton	Spun silk	Spun rayon	Rayon
Dry strength	73	68	100	80	53	64
Wet strength	81	78	100	63	40	45
Dry knot strength	78	75	83	100	43	47
Wet knot strength	100	95	98	85	39	30
Elastic recovery	99	100	96	94	85	69
Flex resistance	95	100	41	16	15	4
Sewability	96	100	100	88	64	56
Abrasion resistance	68	100	36	54	54	18
Strength after laundering	58	55	100	28	45	41
Index number	83	86	84	68	49	42

of equal weights by Walz at Reutlingen results in different relative index numbers for sewing threads made from various fibers from those given by Gütermann.

4. Research on Comparison of Sewing Threads by Reutlingen Research Institute

The German Research Institute for the Textile Industry at Reutlingen was commissioned by the sewing-thread industry to make a scientific comparison and evaluation of the various types of sewing thread. The physical properties of the sewing threads were determined in accordance with the usual procedure on the regular testing instruments. The tests included the following: breaking strength per unit of cross section tested dry; breaking strength per unit of cross section tested wet; breaking length of sewing thread tested dry, with a simple knot tied in the specimen; breaking length of sewing thread tested wet, with a simple knot tied in the specimen; elastic recovery; resistance to flexing; resistance to abrasion (Jansen tester); sewability (number of breaks on a commercial sewing machine per 3,600 stitches); and breaking strength after 30 launderings. The results are given in Table XI on a percentage basis. For each property, the thread having the highest value is given a value of 100 percent. The values for the other threads are given as percentages of the highest value. The average of the nine values of a thread is the index number. It will be noted that cotton sewing thread has the highest index number and rayon sewing thread has a low index number. The mercerized cotton thread has a low resistance to flexing and abrasion. The low resistance to abrasion is probably caused by the flexing produced in the Jansen abrasion tester.

5. Qualitative Criteria for Staple Rayon According to Böhringer

The qualitative criteria for staple rayon proposed by Böhringer [1] are based upon the work carried out at the Textile Research Laboratories of the ZKR (Zellwolle- und Kunstseide-Ringes, G. m. b. H.) at Schwarza. This work involved extensive measurements on many fibers for the following properties: breaking strength, unevenness, elasticity, elongation, knot and loop strength, wet strength, fatigue, flexural endurance, degree of polymerization, swelling, fiber splintering, abrasion, ageing, and internal fiber stresses. Correlations of the results among these properties for the different kinds of fibers were studied. On the basis of these correlations, the mutual interdependence among eight of these properties which affect serviceability was arrived at; this is shown schematically in Figure 32. These eight properties are tensile strength, elasticity or specific elastic work, knot strength, elongation, relative wet strength, tensile fatigue resistance, flexural endurance, and degree of polymerization. The numerical values for these properties are given in Table XII for nylon, wool,

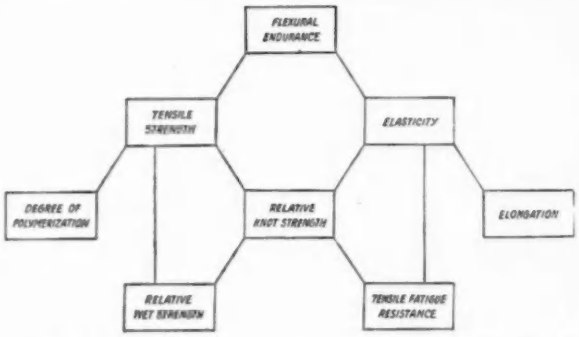


FIG. 32. *Schematic drawing showing relationship between the properties of textiles which affect serviceability.*

TABLE XII. PHYSICAL PROPERTIES OF FIVE KINDS OF FIBERS

Kind of fiber	Tensile strength (kg/mm²)	Elasticity (Specific elastic work in kg/cm³)	Relative knot strength (%)	Elongation at break (%)	Relative wet strength (%)	Tensile fatigue resistance (%)	Flexural endurance (cycles)	Average degree of polymerization *Z*	Fineness *Nm*
Nylon	54.5	2.81	86	25	87	94	244000	—	2790
Wool	17.8	1.94	85	34	82	100	156000	—	2600
Silk	65.1	2.92	88	31	79	93	76300	—	9450
Cotton	43.5	0.427	91	11	98	64	64750	3130	5770
Rayon	29.0	0.661	58	17	61	88	6800	330	5800

silk, cotton, and rayon. The fineness of these fibers is also given for information. Since the units for these properties are different, it is necessary to convert them to some common basis before they can be combined into a quality index. For this purpose the values of the properties of rayon are arbitrarily taken as 100 and the values of the properties for the other fibers are expressed as percentages of the corresponding values for rayon. These values are given in Table XIII. The average value for each fiber is taken as the quality index. The quality index values for nylon, wool, silk, cotton, and rayon are 678, 463, 336, 232, and 100, respectively. The value for rayon is an average one. For different rayons and staple rayons the quality index varies from a low of 68 to a high of 199. Judgment must be exercised in using this quality index of fibers intended for radically different uses. Indiscriminate use would of course lead to erroneous conclusions.

A comparison of these indices, however, may be of theoretical interest and may lead, in future developments of this testing technique, to new knowledge regarding fibers and their serviceability. The scheme described here is certainly not final, but it may be a step in the right direction. The adequacy and significance can be determined only from carefully conducted systematic service tests. Such tests would be time-consuming but would yield worthwhile results which would fully justify the time and expense involved.

TABLE XIII. RELATIVE VALUES OF PHYSICAL PROPERTIES OF FIVE KINDS OF FIBERS

Fiber property	Nylon	Wool	Silk	Cotton	Rayon
Tensile strength	188	61	224	150	100
Elasticity	422	287	439	64	100
Knot strength	149	147	151	157	100
Elongation	148	202	182	65	100
Relative wet strength	143	135	130	161	100
Tensile fatigue resistance	106	114	106	73	100
Flexural endurance	3590	2295	1123	952	100
Degree of polymerization	—	—	—	950	100
Average = Quality index	678	463	336	232	100

6. Serviceability Evaluation According to Stoll

Probably some of the most extensive, systematic, and thorough research undertaken for the evaluation of the quality of textiles is that of the Research Institute of the Southern German Staple Rayon Company at Kelheim (Forschungsinstitut der Süddeutschen Zellwolle, A. G., Kelheim) under the direction of R. Stoll [2–7]. In this work a careful analysis was made of this very complex problem and a classification of the properties to be measured was prepared. In the evaluation of the quality of a textile, the purpose which the textile is to serve must be considered. Thus, for spinning, twisting, weaving, knitting, etc., certain properties of the fibers are important and must be evaluated as a measure of their quality. Similarly, for durability, for appearance and good fit, for hygiene and comfort, and for special uses such as coating, electric insulation, etc., different properties must be measured to evaluate the quality of textiles for these uses. For some of these uses, the same properties are involved but their relative importance may vary. For this purpose Stoll suggested a system of weighting the results—namely, a weight of 0 is used when a property is not important for a given use and a weight of 4 is used when it is very important. Weights of 1, 2, and 3 are used to indicate intermediate importance. A schematic diagram indicates the property to be measured and the weight of relative importance for fifteen different uses of textiles. Schematic diagrams outline the types of failures, their causes, and the testing methods and instruments, with literature ref-

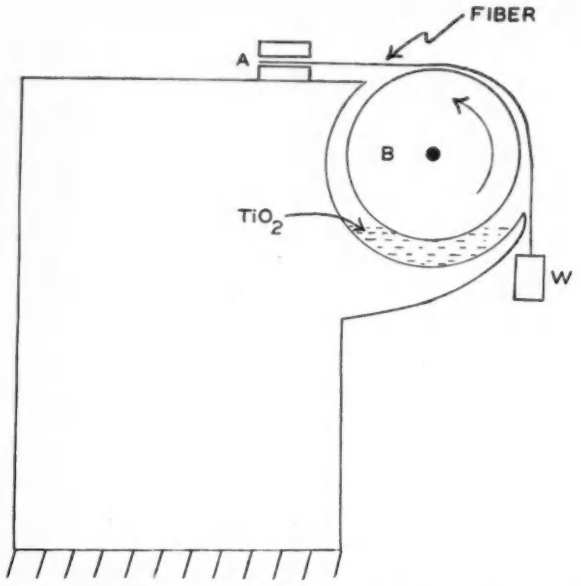


FIG. 33. *Zart single-fiber abrasion tester.*

erences, to be used for the measurement and evaluation of the various properties and characteristics of textiles. For the evaluation of some properties and characteristics, new instruments were developed.

In the extensive investigations on the evaluation of the serviceability of staple rayon, systematic experiments were carried out, beginning with the raw material and ending with the wearing of the finished textiles. Comprehensive tests were made to evaluate such factors as the effects of two different wood pulps and four different viscose spinning procedures on the quality of the fibers produced, and on the properties of yarns and fabrics made from them. The effects of seven different deniers of the fibers on their quality and on the properties of yarns and fabrics made from these fibers were similarly studied. A quality index of these different fibers was computed. This index was based upon the wet strength, knot strength, and degree of elasticity. The computation was made by expressing the numerical values of these properties for a fiber as percentages of the corresponding values for American cotton. The values for the American cotton were 25 km., 24 km., and 50 percent, respectively, for wet breaking length, knot breaking length, and degree of elasticity. The average of the three percentages for a fiber was taken as its quality index. These indices were found to be in good agreement with the results of the tests on the finished fabrics and after 25 launderings.

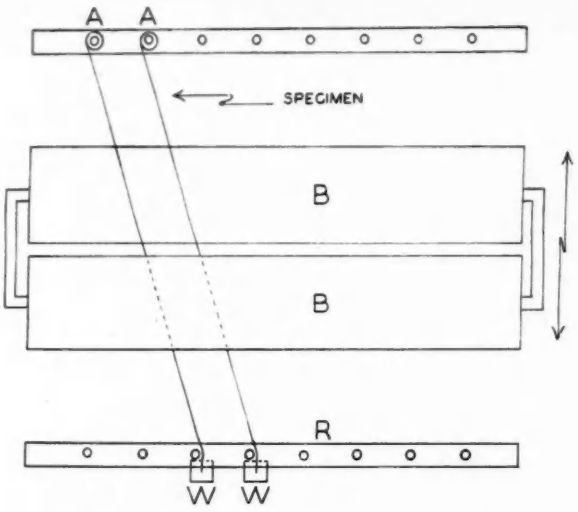


FIG. 34. *New Zart abrasion tester, top view.*

Stoll's work merits very careful study. The results of a major part of this work, especially that part pertaining to the results of actual service tests and correlations with the results of laboratory tests of the fabrics, yarns, and fibers, have not been published. This phase of the work, which is now being completed by Stoll, will ultimately be made available to the American textile industry. The results of this work should add greatly to a clearer understanding of this complex problem of evaluation of serviceability of textiles.

7. Serviceability Evaluation According to Ramsthaler

The evaluation of the influence of fiber fineness and staple length on the serviceability of staple rayon fabrics was carried out in the textile laboratories of the Saxony Staple Rayon Company at Plauen (Textillaboratorium der Sächsischen Zellwolle, A.

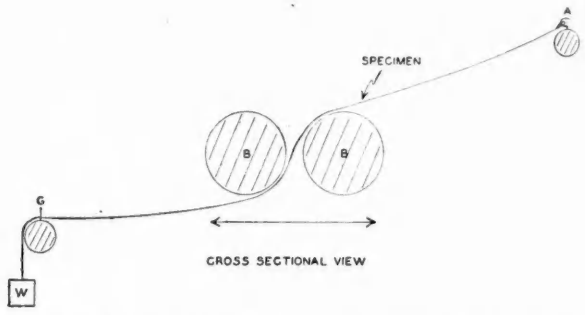


FIG. 35. *Schematic drawing of the new Zart abrasion tester, cross-sectional view,*

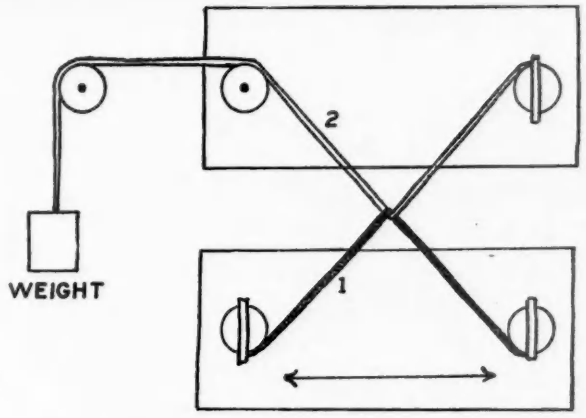


FIG. 37. *Jansen yarn abrasion tester.*

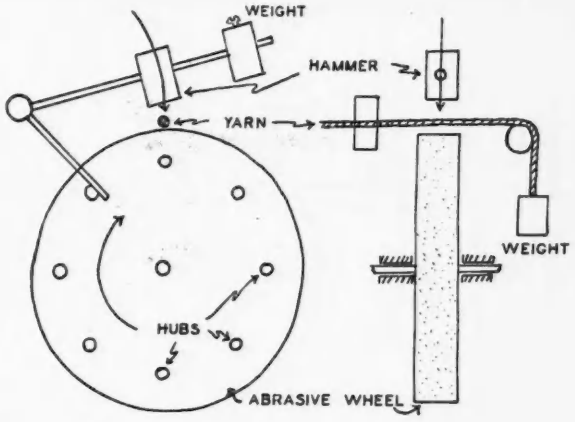


FIG. 38. *Mecheels yarn tester.*

G., Plauen) under the direction of K. Ramsthaler [8]. The fabrics were made from (*a*) 1.5-denier, 38-mm. staple rayon, (*b*) 2.2-denier, 50-mm. staple rayon, and (*c*) 2.75-denier, 60-mm. staple rayon. The three finished fabrics were tested, 46 different test results being reported for each. The yarns taken from the three finished fabrics were tested, 28 different test results being reported. The fibers taken from the three finished fabrics were also tested, 29 different test results being reported. The fabrics were also tested after 1, 10, 25, 50, 75, and 100 launderings, 46 different test results being reported for each fabric after each of these launderings. Nine properties of the fabric, two properties of the yarn, and four properties of the fiber were combined to obtain an index of quality. In this calculation the values obtained on the fabrics after the six different numbers of launderings were used to obtain the relative rank. For a given property a value of 1 was assigned to the fabric which was best in that property. A value of 3 was assigned to the fabric which was poorest in that property. A value of 2 was assigned to a third fabric which was intermediate with respect to this property. This procedure was repeated for each of the other fourteen properties and for each of the six different numbers of launderings. The sum of the sixty numbers, thus assigned to each of the three fabrics, was taken as an index of quality, the lowest number indicating the best quality, and vice versa. The fabric made from the 2.2-denier, 50-mm. staple rayon was best, with an index number of 150. The fabric made from the 1.5-denier, 38-mm. staple rayon was second best, with an index number of 161. The fabric made from the 2.75-denier, 60-mm. staple rayon was poorest, with an index number of 229. The values obtained by dividing 1,000 by the index numbers were taken to indicate the relative durabilities of the three fabrics; hence if the best fabric was taken as 100 percent, the next best was 93 percent, and the poorest was 66 percent. The fabrics were also used in actual service tests. The results of these service tests were not available. In the most recent report, laboratory and service-test results are compared on five different fabrics and two different finishes [32].

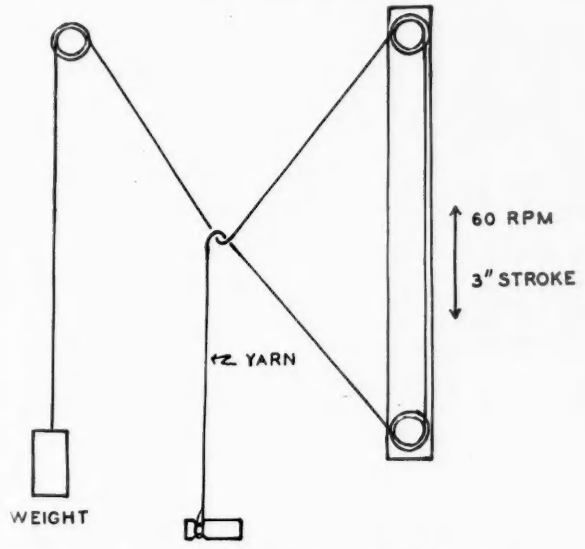


FIG. 36. *Oestermann yarn abrasion tester.*

8. Serviceability Evaluation According to Wagner

The evaluation of the influence of finish of staple rayon fabrics for men's sport shirts was carried out at the Official Testing Laboratory for Textiles at Wuppertal (Städt. Öffentl. Warenprüfungsamt für

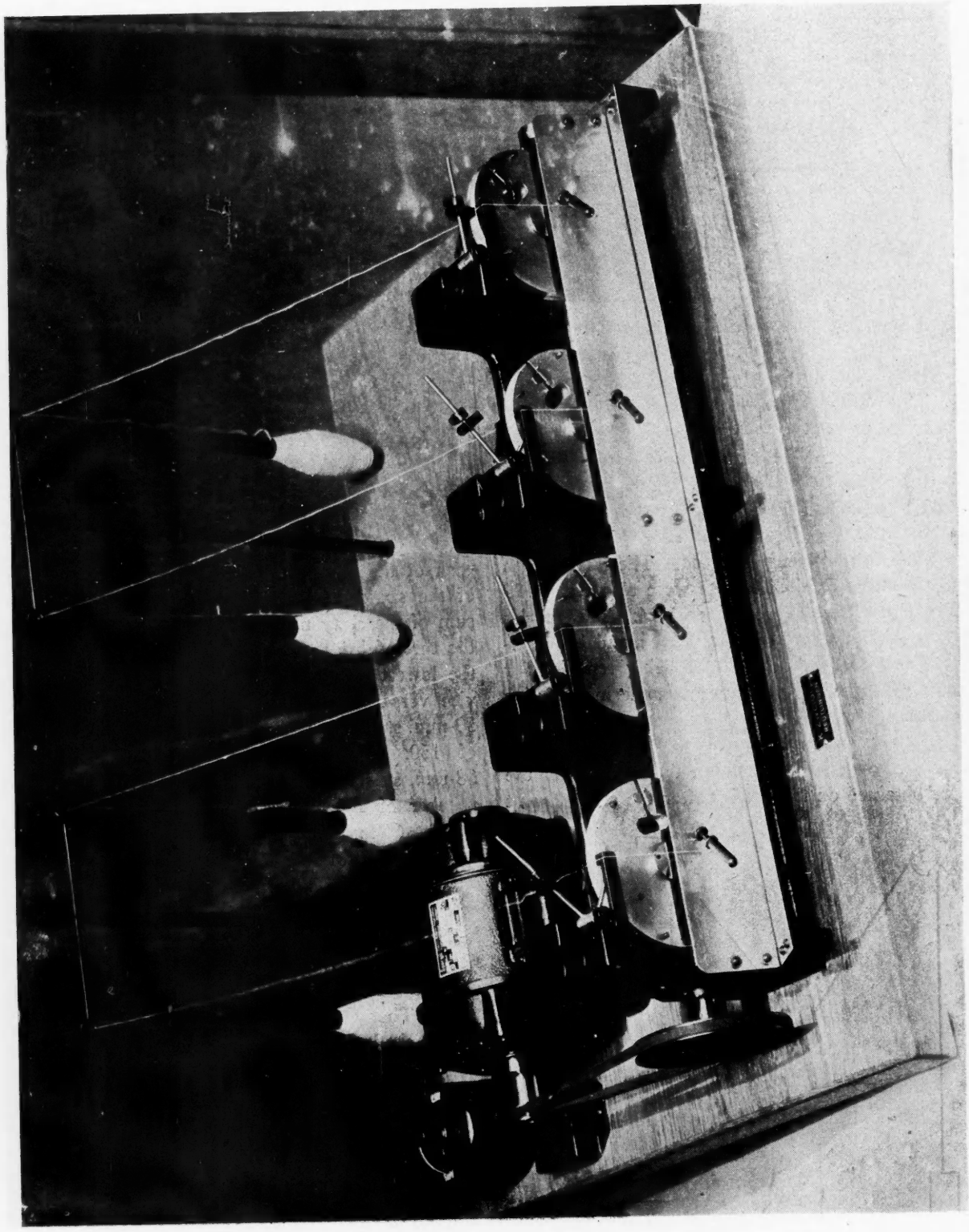


FIG. 39. *Mecheels yarn tester.*

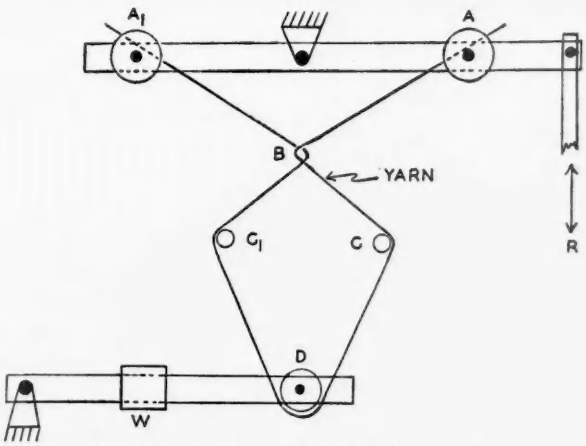


FIG. 40. *Aachen yarn abrasion tester.*

das Textilgewerbe, Wuppertal) under the direction of Dr. E. Wagner [9]. Warp and filling yarns were spun from normal viscose staple rayon according to definite specifications. The properties of the staple rayon and of the warp and filling yarns were measured in the usual thorough manner. Five thousand meters of poplin were woven from these yarns. The fabric was divided into fourteen portions, thirteen of which were given different finishing treatments. Some fifty odd properties of these fourteen fabrics were measured on the unlaundered fabrics and also after 1, 10, 25, and 50 launderings. These tests included dry and wet abrasion using the Schopper, Repenning, Müller, Anderlitschka, I. G. Farben edge, and Weltzien folding abrasion testers. The fourteen fabrics were made into men's sport shirts for actual service tests, which were carried out independently at two places, Wuppertal and Berlin. Each of the shirts which were worn at Wuppertal was made from fabrics of two different finishing treatments. Each man was given three shirts to wear. Each shirt was worn two days, washed, ironed, measured, and judged or scored for wear. The shirts worn in

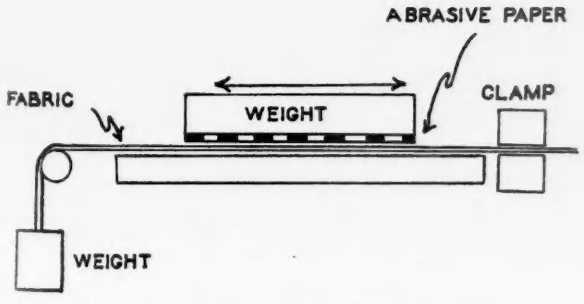


FIG. 42. *Müller fabric abrasion tester.*

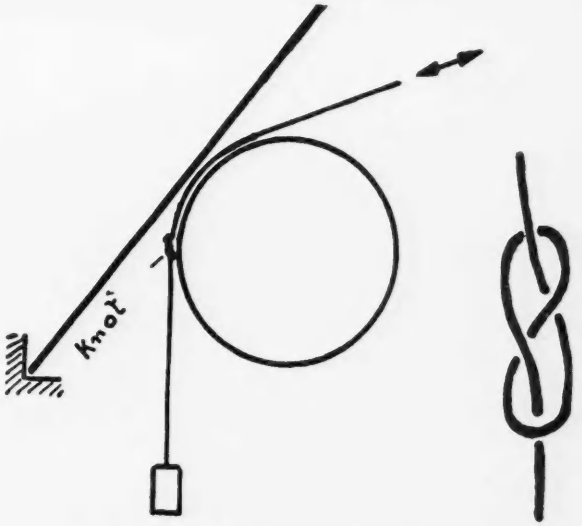


FIG. 41. *Abrasion tester on knots in yarns.*

Berlin were made of only one fabric of a given finishing treatment. After a shirt was worn, washed, ironed, and judged or scored, it was then given to another man for the next wearing. Laboratory tests were also made on the fabric cut from the shirts at stated periods during the service wear tests. The effects of laundering on the various properties were shown graphically. No scheme was suggested for combining the results of the laboratory tests into a quality index. However, the laboratory abrasion results obtained with the various instruments were compared by arranging the fourteen fabrics in the order of good-to-poor for each abrasion test. In the seven tests made on the unlaundered fabrics, the four best fabrics were nos. 21, 14, 18, and 10, and the four poorest fabrics were nos. 13, 27, 26, and 29. After one laundering the order, determined by four methods of testing, of the four best fabrics was again nos. 21, 14, 18, and 10, whereas the order of the four poorest was nos. 26, 13, 27, and 29—still the same fabrics but arranged in different order. After 50 launderings the three best fabrics, determined by six methods of testing, were nos. 16, 1, and 21, and the three poorest were nos. 26, 27, and 13, in the order given. It will be noted that only no. 21 was consistently among the best fabrics, whereas nos. 26, 27, and 13 were always in the poorest group.

The results of the service tests conducted at Wuppertal indicated that abrasion of the collar and cuffs was the predominant cause of failure. The effect of laundering was slight. The four fabrics which were judged poorest by the dry abrasion tests wore out at

FIG. 39. *Mecheels yarn tester.*

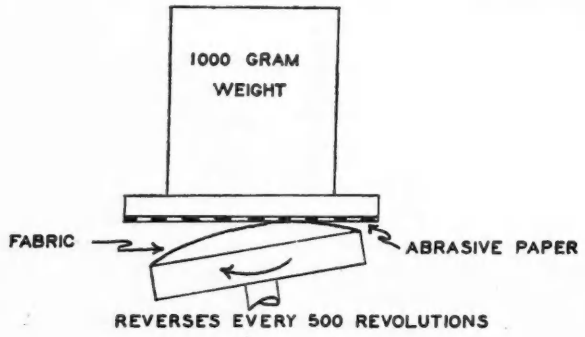


FIG. 43. *Schopper abrasion tester.*

the greatest rate in these service tests. The service tests conducted at Berlin indicated that damage due to laundering was the predominant cause of failure. This was partly due to the different method of laundering and also to the fact that the students who wore the shirts rolled up the sleeves, which minimized wear on the cuffs. The fabrics judged poorest by the wet

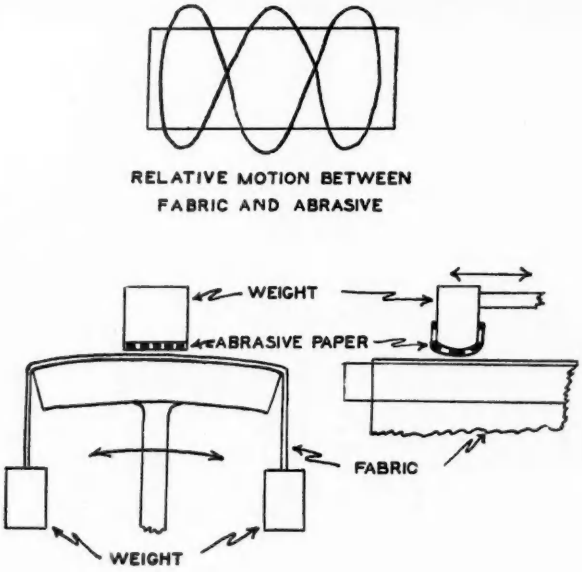


FIG. 45. *Repenning abrasion tester.*

FIG. 44. *Schopper abrasion tester.*

abrasion tests showed the greatest rate of wear in these service tests.

9. Abrasion Testing Machines

(*a*) *Zart Fiber Abrasion Tester*

An instrument was developed by Zart [13] for testing the resistance to abrasion of single fibers; this is shown schematically in Figure 33. The fiber is clamped at *A*, passed over the drum *B*, and a weight *W* is suspended from the free end. The drum *B* was partly enclosed by a trough which contained a solution of titanium oxide. The drum, which was 10 mm. in diameter and 30 cm. long, rotated and also had a slight reciprocating motion along its axis so that the

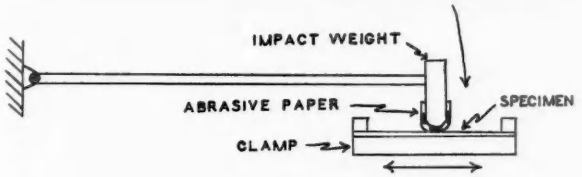


FIG. 46. *Repenning carpet wear tester.*

fiber received both a lengthwise and a sidewise abrasion by the titanium oxide which was carried on the drum surface. Twenty fibers could be tested simultaneously. The number of revolutions required to rupture the fiber was recorded. It was stated that the results were so variable that they were meaningless. Zart made an improvement of this machine, which is shown schematically in Figures 34 and 35. This instrument could also be used to test yarns. In this tester the two horizontal cylinders *B*, which are covered with an abradant, usually emery paper of 500-A quality, are reciprocated horizontally. The specimen fastened at *A* is passed over one cylinder, then between the two cylinders, and under the second cylinder and over a rod *R* at guide *G*, and a weight *W* is suspended from the free end. It is important to note that the line *A* to *W* is not at right angles to the axis of the cylinders *B*. The specimen is therefore abraded lengthwise and also sidewise.

(*b*) *Yarn Abrasion Tester*

In the yarn abrasion tester used by Oestermann, shown in Figure 36, one end of the yarn is fastened to a fixed clamp. The yarn is then passed over two guides which are positioned one above the other on a vertically reciprocating arm. The yarn is passed underneath the yarn portion between the fixed clamp and the first (lower) guide and then over a pulley situated at about the same height as the second (upper) guide, and a weight is suspended from the free end. The fixed clamp is located approximately midway (measured horizontally) between this pulley and the two guides of the reciprocating arm. The arm reciprocates up and down about sixty times per minute through a distance of 3 inches. The yarn is abraded against itself; the position at which the yarn crosses itself moves up and down through a distance of about 1½ inches. The number of reciprocations required to rupture the yarn is recorded.

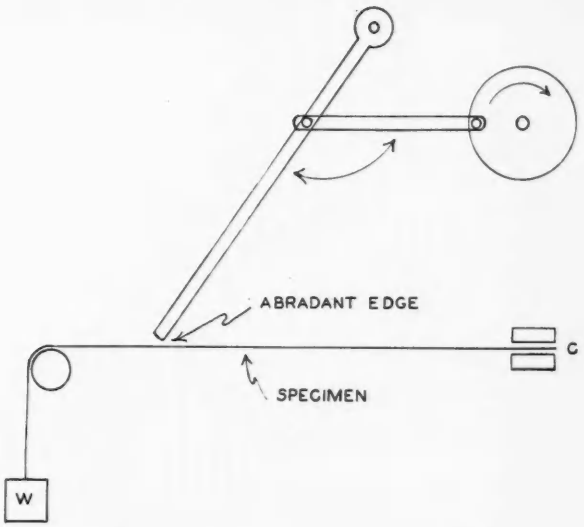


FIG. 49. *Weltzien abrasion tester.*

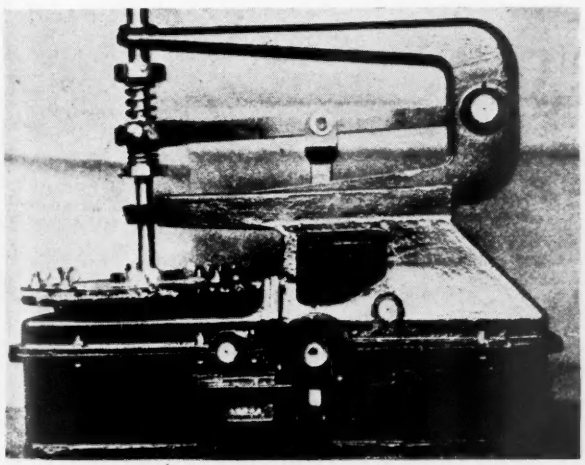


FIG. 47. *Scheid carpet wear tester.*

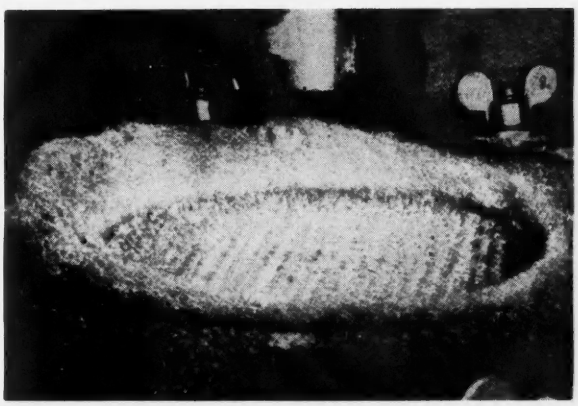


FIG. 48. *Worn specimen of carpet being tested with the Scheid instrument.*

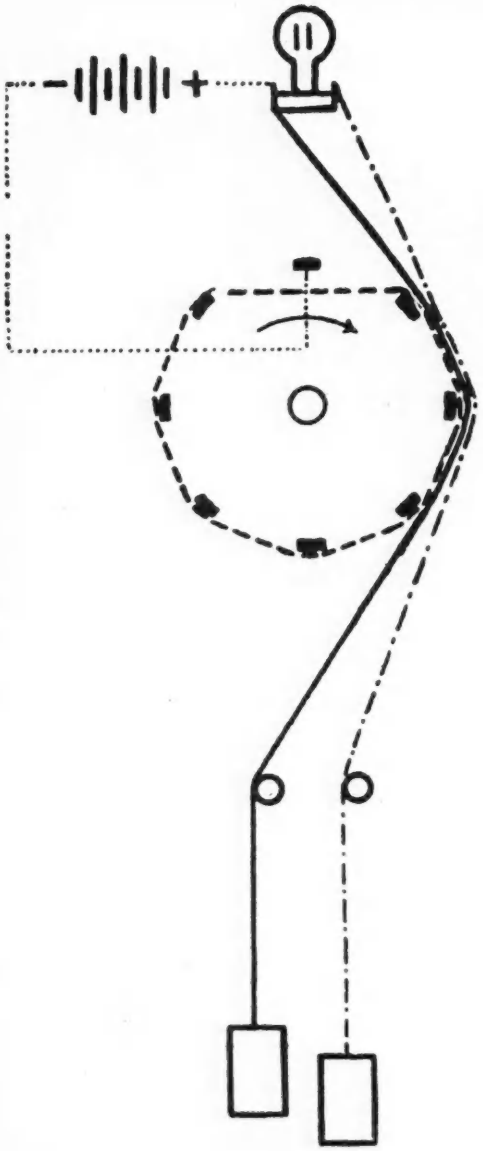


FIG. 50. *I. G. Farben edge abrasion tester.*

(c) *Jansen Yarn Tester*

In the Jansen yarn tester, shown in Figure 37, one yarn is fastened to two clamps of a horizontally reciprocating member. A second yarn is fastened at one end to a fixed clamp, passed underneath the middle of the first yarn, and then over two pulleys, with a weight attached to the free end. The two yarns are abraded against each other until one of them breaks. The number of reciprocations necessary to cause failure is recorded.

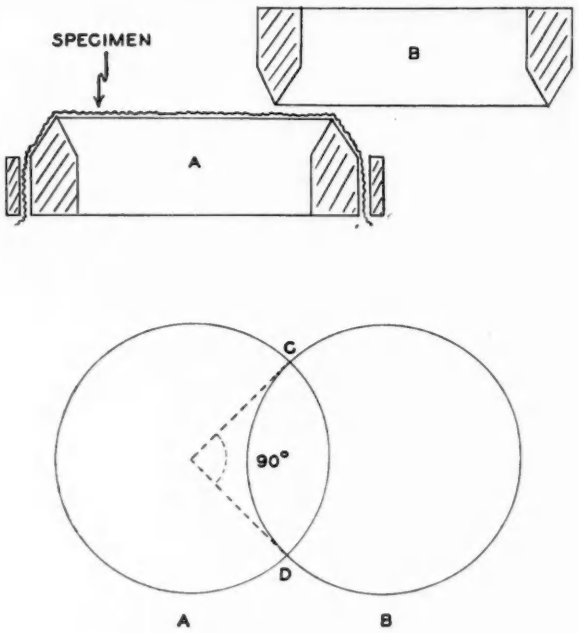


FIG. 51. *New I. G. Farben edge abrasion tester.*

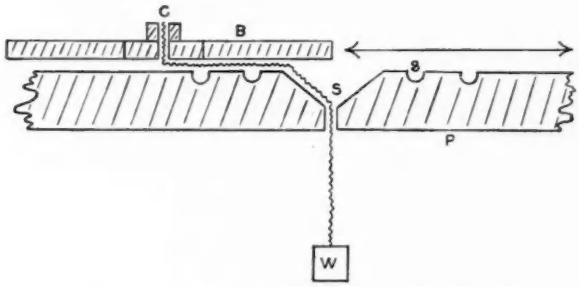


FIG. 52. *Anderlitschka abrasion tester.*

(d) *Mecheels Yarn Tester*

The Mecheels yarn tester is shown in Figures 38 and 39. The yarn is fastened at one end in a horizontal clamp and is then passed over a pulley, with a weight attached to the free end. The horizontal portion of the yarn between the clamp and the pulley passes over a rotating abrasive wheel without making actual contact. A weighted hammer is actuated by eight hubs of the abrasive wheel which allows the hammer to strike the yarn, press it against the abrasive wheel, and hold it in contact for a short interval. It is then lifted and the cycle of impact, abrasion, and relaxation is repeated. The number of cycles required to produce rupture is recorded. Four yarns can be tested at one time.

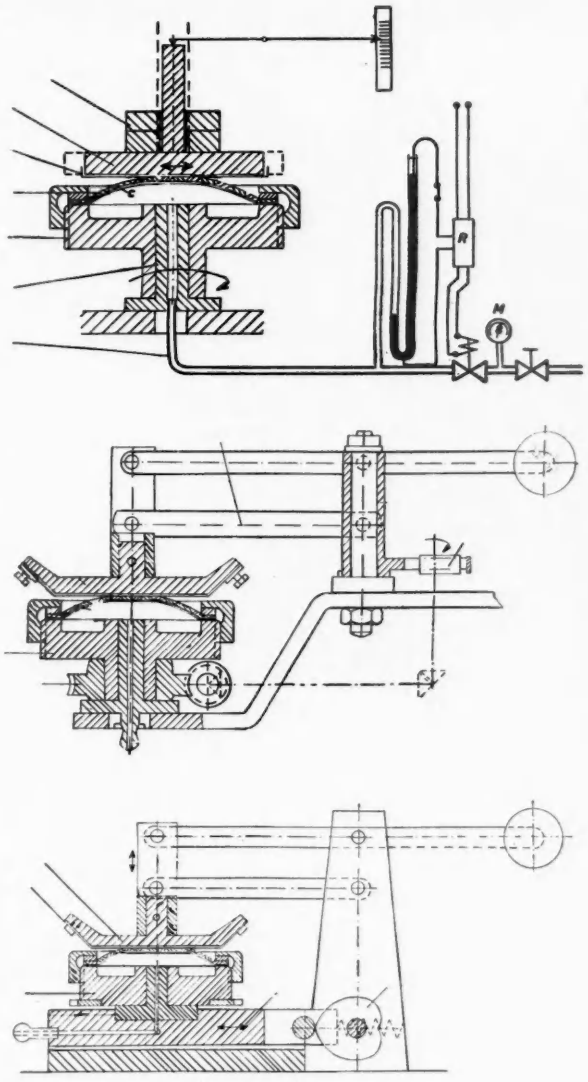


FIG. 53. *Stoll abrasion tester.*

(e) *T. H. Aachen Yarn Abrasion Tester*

The yarn abrasion tester developed at the Technischen Hochschule at Aachen is shown in Figure 40. The ends of the yarn specimen are clamped at A and A_1 to a bar which is oscillated up and down by the reciprocating rod R. The yarn crosses itself once at B, passes around the two small pulleys C and C_1 and under the pulley D, which is located at the end of a beam to apply a tension to the yarn which can be adjusted by moving the weight W. The number of oscillations required to rupture the yarn at B is recorded. Matthes and Keworkian made extensive tests with this instrument on yarns of different fibers and different amounts of twist [14]. These tests were performed with various tensions on yarns of different deniers. A quality index S is given by the equation $S = Nm^2 \cdot X$, where Nm is the metric number and X is the number of reciprocations. In a recent paper [33] a new model is described and interesting results are presented which show the relation of the amount of twist on the resistance to abrasion of yarns made from different fibers.

(f) *Knot Abrasion Test for Fibers and Yarns*

An arrangement for testing the resistance to abrasion of knots in fibers or yarns is shown schematically in Figure 41 according to Ecker [15]. The fiber with the knot is fastened to a reciprocating mechanism, passed over a rod, and a weight is suspended from the free end. A ground-glass plate presses against the yarn at the midpoint of the arc of contact. The fiber is so mounted that at the middle of the reciprocation the knot is also at the midpoint of the arc of contact. During each reciprocation there is a slight impact on the knot as it passes between the ground-glass plate and the rod, as well as abrasion. The number of reciprocations necessary to cause failure of the knot is recorded.

(g) *Müller Fabric Tester*

The Müller fabric abrasion tester is shown in Figure 42. One end of a fabric strip is fastened in a fixed clamp and the fabric is passed over a horizontal plate and a pulley, with a weight attached to the free end. A reciprocating weight with an abrasive paper on the under side is brought in contact with the fabric above the horizontal plate. The weight reciprocates back and forth and abrades the fabric in the direction of the applied tension. The change in breaking strength with the number of reciprocations is measured [31].

(h) *Schopper Abrasion Tester*

The Schopper abrasion tester is shown in Figures 43 and 44. The fabric is clamped over a circular convex surface which rotates and reverses in direction of rotation after a specific number of rotations. A weight with an abrasive paper on the under side is brought into contact with the fabric. The axis of the rotating member makes an acute angle with the surface of the abrasive paper. The decrease in

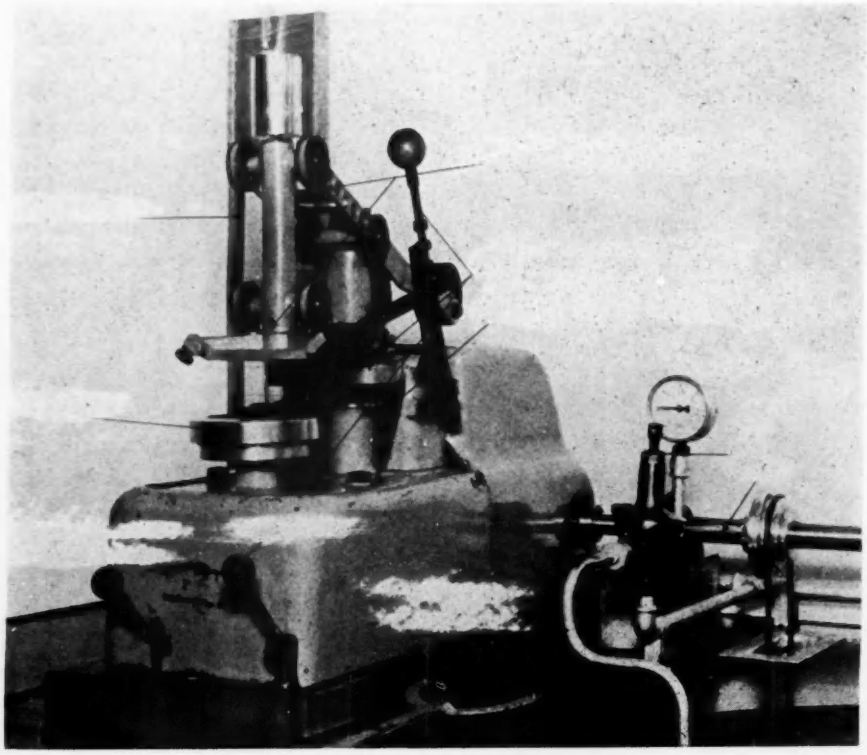


FIG. 54. *Stoll abrasion tester.*

bursting strength with the number of rotations and the number of rotations necessary to produce a hole are determined [31].

(i) Repenning Abrasion Tester

The Repenning abrasion tester is illustrated in Figure 45. The fabric is fastened to an oscillating surface under a constant tension produced by weights suspended from the two ends. The contact surface, which is cylindrical, is preferably made of a yielding material. A weighted arm which has an abrasive paper fastened to the under side over a slightly convex surface is brought into contact with the fabric. The arm reciprocates horizontally at right angles to the direction of the oscillation of the cylindrical surface. The periods of oscillation and reciprocation are unequal, so that the relative motion of the abrasive paper to the fabric is of a variable and multiple figure-8 type. The number of oscillations required to produce a hole is recorded.

(j) Repenning Impact and Abrasion Tester

The Repenning impact and abrasion tester, designed primarily for carpets and pile fabrics, is illustrated in Figure 46. The fabric is fastened to a horizontal reciprocating plate. A weighted impact arm with an abrasive paper on the under side is actuated by an eccentrically positioned hub of a rotating disc. The frequency of impact exceeds the number of reciprocations, so that the impact occurs at different positions of the fabric. The number of impacts necessary to produce a hole is recorded. This type of tester has been used by Oestermann on knitted fabric to obtain pure impact failure by omitting the reciprocation of the fabric.

(k) Scheid Carpet Wear Tester

The machine for testing the wear-resistance of carpets developed by Scheid [16] is shown in Figure 47. A worn specimen is shown in Figure 48. In this test the specimen of carpet is mounted on a rotating disc. The abradant is fastened to the bottom of a small disc which is periodically raised off the specimen by a cam and then allowed to drop and rest on the rotating specimen.

(l) Weltzien Abrasion Tester

The abrasion tester developed by Weltzien is shown schematically in Figure 49. The specimen is fastened to a clamp and placed under tension by a spring or a weight W attached to the other end. The abradant is fastened to the end of an arm which is rocked back and forth through an angle of 90 degrees. By placing a shallow dish containing water underneath the specimen, that portion which has been abraded can be kept wet during the test.

(m) I. G. Farben Edge Abrasion Tester

The edge abrasion tester developed at the I. G. Farben, Werk Höchst, is shown schematically in

FIG. 55. *Stoll abrasion tester.*

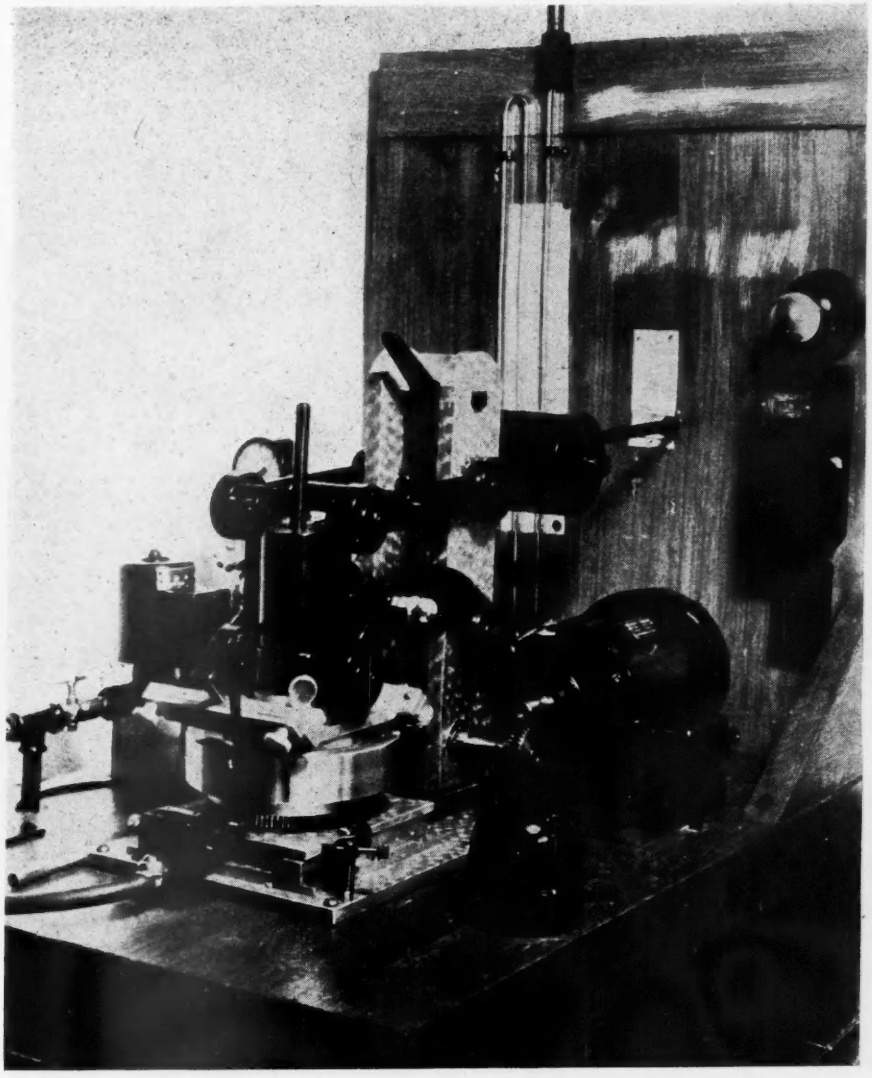


Figure 50. The abradant is fastened around seven rods of an eight-rod, squirrel-cage, horizontally rotating cylinder. The eighth rod, which is bare, is part of an electrical circuit. The specimen is fastened above the center of the cylinder and passes around one side and over a small rod located directly below the center of the cylinder. A weight is suspended from the free end. A wire, which is also part of the electrical circuit, is similarly mounted and bears against the specimen. The squirrel cage rotates until a hole is worn through the specimen, at which time the wire and the bare rod make contact and a signal is given or the machine is stopped. Results obtained with this tester have been reported by Wagner [9]. In general, the results were quite variable and not considered to be satisfactory.

(n) New I. G. Farben Abrasion Tester

The new I. G. Farben abrasion tester is shown schematically in Figure 51. The specimen is mounted with constant tension over the metal cylinder *A* with specially shaped rims of hardened, polished steel, using a special mounting setup to apply the tension. A similar metal cylinder *B* rests, with a definite pressure, on the specimen. The cylinder *B* is placed eccentrically with respect to cylinder *A* so that the central angle subtended by the intersecting chord *CD* is 90 degrees. The diameter of the two cylinders is 17 mm. Both cylinders rotate with a speed of 300 r.p.m. but in opposite directions. The tests may be made with cylinder *B* bare, or, if desired, it may also be covered with a specimen which serves as the abrader. The end of the test is indicated by an electrical contact between the two rotating cylinders. The tension in mounting the specimen may be adjusted to values between 500 and 2,000 grams and the downward force of cylinder *B* on *A* may be adjusted to values between 50 and 500 grams. These values are so selected that the duration of a test is between 20 and 100 seconds. A full report on the results obtained with this machine has been made by the Synthetic Fibers Team of the Technical Industrial Intelligence Committee [30].

(o) Anderlitschka Tester

The fabric tester developed by Anderlitschka [17] is shown schematically in Figure 52. The fabric is

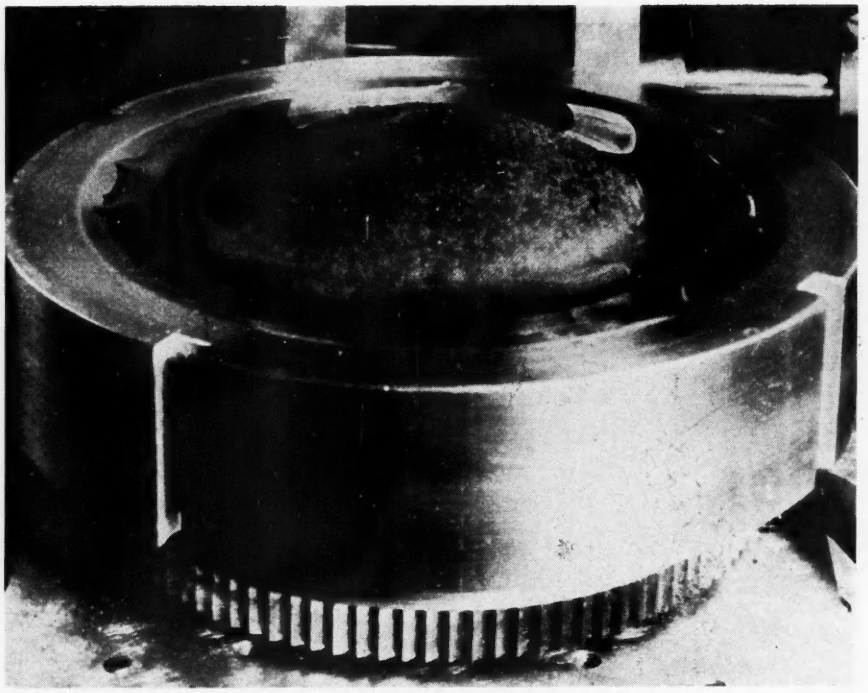


FIG. 56. *Clamp for Stoll abrasion tester.*

fastened in clamp C of a reciprocating plate B. It is passed through a slot S of a fixed plate P and a weight W is suspended from the free end. During a test, the fabric is pulled through the slot S and is abraded by the edges of the slot and of the grooves g under the pressure of the plate B, first on one side and then on the other in each reciprocation of the plate B. In addition to these actions, the fabric is also flexed. Results obtained with this tester have been reported by Wagner [9] and Koch [31].

(*p*) *Stoll Abrasion Testers*

The abrasion machine designed by Stoll [7] is shown schematically in Figure 53. Two models of the machine are shown in Figures 54 and 55. A close-up view of the specimen and clamp during a test is shown in Figure 56 and the appearance of a worn-out specimen is shown in Figure 57. The specimen is mounted in a special clamp over a diaphragm which is inflated with compressed air to apply a tension on the specimen during the test. The clamp holding the specimen is attached to a plate which is reciprocated back and forth by a cam. The abradant is fastened to the bottom of a plate

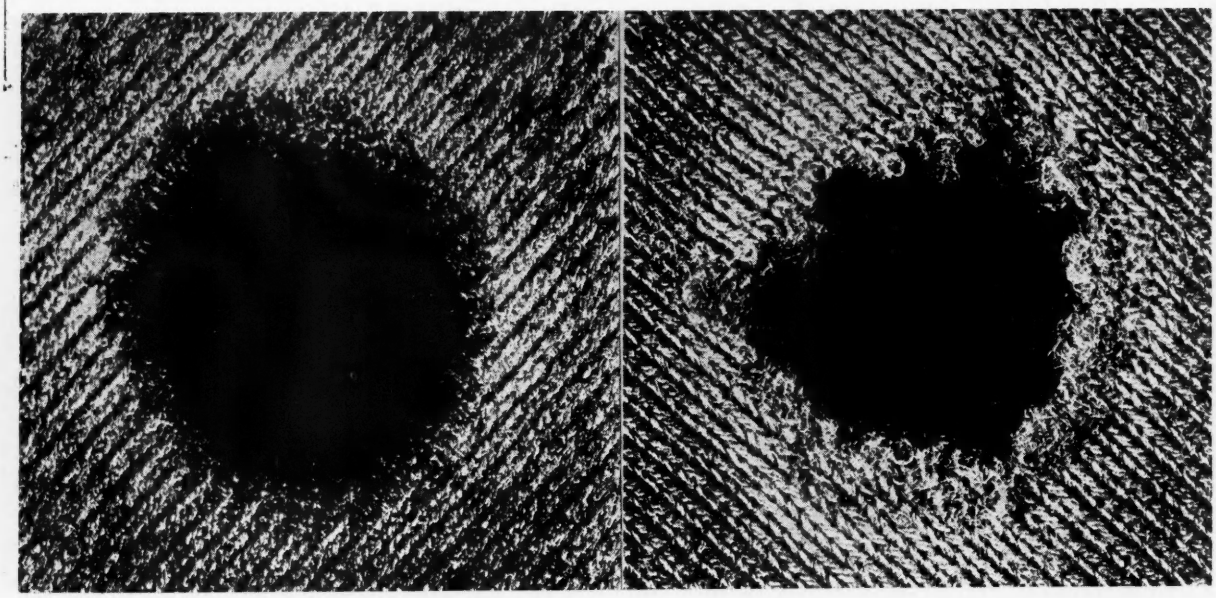
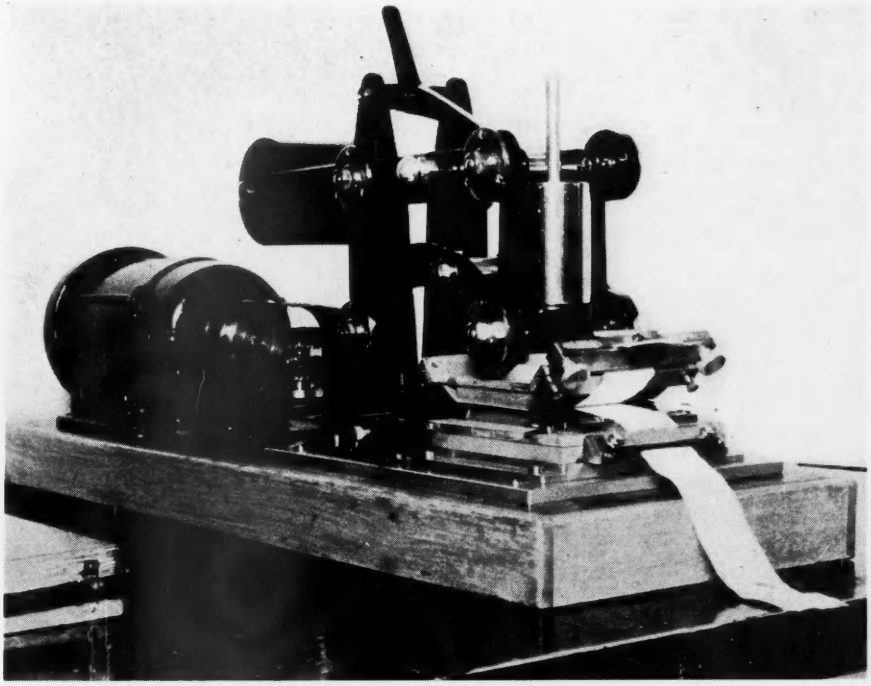


FIG. 57. *Worn specimens after being tested with the Stoll instrument.*

FIG. 58. *Stoll's new abrasion tester.*



which can be moved up and down by a system of two horizontal and two vertical levers. These levers also serve for applying a known downward force on top of the specimen. The relationship between the tension applied to the specimen and the duration of the test was found to be a power function—that is, it is linear when plotted on logarithmic graph paper. The specimen can be tested wet by filling the depression between the fabric and the clamp (see Figure 56) with water.

In another design the specimen is flexed and abraded against itself. This machine is shown in Figure 58 and a schematic diagram is shown in Figure 59. The specimen is clamped to the left edge of the bottom plate (Figure 59), then folded over to the middle of the bottom plate and then back on itself, and fastened to the left edge of the upper plate. The folded specimen is compressed between the two plates under a known force acting through the upper plate. The bottom plate is reciprocated horizontally, which flexes the specimen and abrades it against itself.

10. Recommendations

In the broad research program on the wear-resistance of textiles consideration should be given to the technique of combining a number of properties of the fiber, yarn, and fabric into a single serviceability index. In this technique it is important that the various properties be first expressed in the same units or reduced to a common basis before they are combined. A scale of weights, depending upon the relative importance of a given property for a given use, should be considered. The information gained from the researches of textile technologists of Germany may prove helpful in problems dealing with the serviceability and wear-resistance of textiles. To facilitate maximum use of the information on German research, references 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14, 18, 27, 31, 32, and 33 of the Bibliography are worthy of translation.

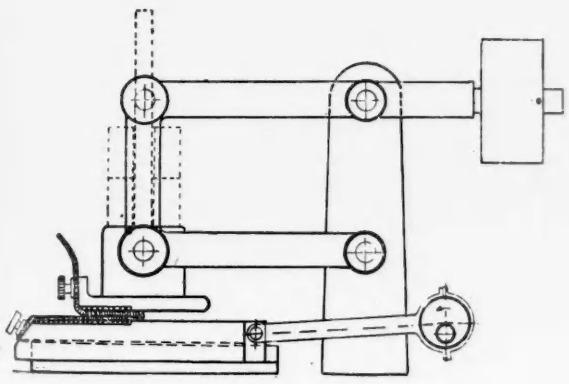


FIG. 59. *Stoll's new abrasion tester.*

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2. Die Qualitätsprüfung von Zellwolle unter besonderer Berücksichtigung der durch Verstreckung erzielbaren Veränderung der physikalischen Eigenschaften. (Testing the quality of rayon staple with special reference to changes in physical properties during stretching.) R. Stoll and E. Rall. *Melliand Textilber.* **20**, 734–7, 783–7 (1939).

A comprehensive discussion of the factors affecting the quality of fibers is given.

3. Über die Qualitätsbestimmung von Textilstoffen und die ursächlichen Zussammenhänge von Gewebe-, Garn- und Fasereigenschaften. (On the measurement of the quality of textile materials and interrelationships between the properties of woven fabrics, yarns, and fibers.) R. Stoll. *Melliand Textilber.* **21**, 270–7, 331–7 (1940).

The complicated relationship between the properties of fibers and utility and durability is explained. Results are given on the properties of staple rayon fibers spun under six different carefully controlled conditions and in seven deniers. The properties of the yarns and of fabrics made from these fibers are reported and discussed. Quality indices for the fibers were computed on the basis of American cotton as standard.

4. Die Verbesserung der Haltbarkeit von Zellwollgeweben durch geeignete Titer- und Stapelwahl. (Improvement of the durability of staple rayon fabrics through selection of most suitable denier and staple length.) R. Stoll. *Melliand Textilber.* **22**, 125–9, 253–5, 308–14 (1941).

The properties of fabrics made from staple rayon varying systematically in denier and staple length were measured and discussed. Particular attention was given to the optimum spinning conditions.

5. Beitrag zur Ermittlung der Arbeitsbestverfahren in der Zellwoll- und Baumwollspinnerei. (Contribution on the optimum spinning conditions of staple rayon and cotton.) R. Stoll. *Melliand Textilber.* **23**, 221–7, 317–22, 373–6 (1942).

6. Systematische Qualitätsprüfung, die Grundlage der Gebrauchswertverbesserung unserer Textilstoffe. (Systematic quality testing, the basis for improving the serviceability of our textiles.) R. Stoll. *Melliand Textilber.* **24**, 211–15 (1943).

A critical discussion of the properties to be measured for the evaluation of quality for a specific use is presented and illustrated schematically.

7. Neue Erkenntnisse und Apparate zur Haltbarkeitsprüfung von Textilstoffen. (New knowledge and instruments for testing the durability of textiles.) R. Stoll. *Melliand Textilber.* **25**, 344–6, 364–7, 385–8 (1944).

Two new wear-testing instruments are described and results are discussed. Certain conditions of the testing machine can be varied, such as tension of the specimen and pressure on the specimen. The effects of systematic changes in testing conditions are shown.

8. Beitrag zur Beurteilung des Einflusses der Faserfeinheit und Faserlänge auf den Gebrauchswert eines Zellwollgewebes (Standardgewebes). (Contribution on the evaluation of the influences of fiber fineness and staple length on the serviceability of a staple rayon fabric (standard fabric).) Kurt Ramsthaler. *Melliand Textilber.* **24**, 422–4, 459–62, 493–7 (1943).

Test results are given for fifteen properties on fabrics made from three different-denier staple rayon fibers, after 1, 10, 25, 50, 75, and 100 launderings. The results for each fabric are combined into a quality index which is based upon the relative rank of the three fabrics after these launderings when judged by each of the fifteen properties. A later paper [32] contains correlations between laboratory and service tests.

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A new fabric tester is described and illustrative test results are given.

18. Ein Beitrag zum Problem der mechanischen Stoffabnutzung. (A contribution to the problem of mechanical wear of textile materials.) J. Ecker. *Melliand Textilber.* **21**, 575–9, 634–6 (1940); **22**, 194–8, 314–8 (1941).

A comprehensive discussion of the mechanical forces which cause wear is given and the types of wear on the fibers are illustrated with numerous photomicrographs.

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Tests for measuring stiffness and coefficient of friction are described and the effects of finishing treatments on these properties are given.

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The results of an interesting microscopic study of soiling of different fibers and of soil removal in different washing procedures are presented. Eighty-eight photomicrographs of fibers when soiled and when washed are presented to show the attachment of the soil and how it is removed in different laundering procedures. A worth-while paper to consult.

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29. Aus der Zellwollforschung: Gebrauchsgewebe aus verschiedenen Faserarten und ihr Gütevergleich. (Staple rayon research: Utility fabrics made from different kinds of fibers and a comparison of their quality.) H. Böhringer and W. Graf. *Melliand Textilber.* **24**, 347–52 (1943).

The properties of fabrics which differed systematically in kind of fiber (nine different fibers) and in fabric construction were measured and the results are discussed.

30. "Synthetic Fiber Developments in Germany." Report by Synthetic Fiber Team of Textile Industrial Intelligence Committee. New York, Textile Research Institute, Inc. (1946), pp. 899–921.

31. Beiträge zur Gebrauchswertprüfung von Baumwoll-, Zellwoll/Baumwoll- und Zellwoll-Geweben mittels Apparaten. (Testing apparatus for the determination of wearing qualities of fabrics made of cotton, staple fiber, or cotton-staple fiber blends.) Paul-August Koch. *Klepzig's Textil-Z.* **45**, 21–3, 24–44, 97–104 (1942).

An analysis of the factors which affect the wearing quality of textiles is given. Comparative tests were made with the Müller, Anderlitschka, and Schopper abrasion machines and the results are given and discussed. (Photostatic copy on file at the Library of the National Bureau of Standards.)

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Wetting of Wool as a Function of the Duration of Fadeometer Exposure

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IT IS generally known that exposure of wool to sunlight or to carbon-arc fading lamps results in a modification of its properties qualitatively described as "damage." At least part of the mechanism of this light "damage" has been suggested [3, 7], and the labile cystine cross-linkage of the wool-protein molecule as usual seems most susceptible to attack. Published tests for measuring light damage which are at least semi-quantitative are the lead-acetate and alkali-solubility tests [4, 8]. Another possibility is suggested by the good correlation observed between duration of exposure to carbon-arc light and wettability; this property does not appear to have been quantitatively discussed in the literature. Although the significance of this correlation is very incompletely understood, it is believed that it indicates a wool-keratin characteristic of fundamental importance.

Experimental Procedure

A weave-room heading of woolen cloth weighing 12.2 ounces per yard at 58 inches, woven from a blend of 50 percent 64/70s scoured Australian wool, 30 percent 64/70s carbonized Australian wool, and 20 percent carbonized, neutralized fine noils, was cleaned in three successive baths of petroleum ether at room temperature, air-dried, and further cleaned in three successive baths of distilled water at 100°F. After air-drying, a rectangular piece 14 × 22 inches was stapled to heavy wrapping paper and the central area was subdivided into twenty 3 × 4-inch rectangles. The cloth was suspended upon the revolving rack (conforming to its circular design) of an Atlas Electric Devices FDA–R Fadeometer and exposed for periods varying from 1 to 400 hours at intervals fixed by the squares of the integers 1 through 20. Selection of these time intervals was guided by results of previous experiments on the fading of dyed wool, where such intervals in general seem to represent most nearly visually equal gradations in fading. After each time interval, one of the rectangles was cut from the cloth and put away in the dark.

The unexposed control and two exposed swatches were examined for spectral reflectance using a Photovolt photoelectric reflection meter with blue, green, and amber filters; from these data the tristimulus values were calculated and the color specifications (dominant wave length, brightness, and purity) were obtained with the help of spectrophotometric charts [2].

Five circles 1 inch in diameter were cut from each swatch with a steel die, and wetting times were determined by placing each circle, exposed side up, on the surface of approximately 800 ml. of distilled water at room temperature in a 1-liter beaker, immersing it, and holding it submerged with an inverted 3-inch, long-stemmed funnel. The hydrostatic head was 3 inches. Time was recorded with a stop watch from the moment of placing the circular swatch on the water surface until it touched the bottom of the beaker. Both mean and median values were calculated for the extremely variable data obtained, since there is doubt as to which is statistically more significant [1]. The greatest variation from the median was also calculated.

A modified alkali-solubility test [4] * was used to gain some idea of the relative extent of damage during exposure; the test which is generally used was too severe in this case.

Additional swatches were treated with buffered lead-acetate solution [8], and the spectral-reflectance readings obtained were interpreted as explained above.

The experiments just described were repeated with a second piece of woolen cloth weighing approxi-

* 0.01*N* NaOH was used instead of 0.1*N*, and the treated swatches were rinsed by overflow with a minimum of turbulence for 1 hour.

TABLE I. COLOR SPECIFICATIONS OF UNEXPOSED AND FADEOMETER-EXPOSED SWATCHES

	Dominant wave length	Brightness	Purity
Unexposed	572	54.5	12
Exposed 100 hrs.	574	54.5	17
Exposed 400 hrs.	575	53.0	26

mately 12 ounces per yard, woven from a blend of 12½ percent carbonized, neutralized Australian noils, 12½ percent Australian noils, and 75 percent 64/70s scoured Australian wool. In an attempt to correct some of the weaknesses of the first trial, individual swatches were exposed in the large masks which are standard accessory Fadeometer equipment. Also, the circular swatches were tested for wettability with the exposed side down.

It should be noted that both pieces selected for these experiments contained carbonized stock.

Results and Discussion

The exposed wool first became whiter, then gradually became yellower with increased exposure. This yellowing effect did not penetrate through to the unexposed side, and a gradually increasing color gradient as well as harshness gradient was noticeable between exposed and unexposed sides as exposure time was increased. Harshness was very pronounced in swatches exposed for the longest periods. Table I gives the color specifications of two exposed swatches for comparison with the unexposed control.

In the first experiment it was observed that the yellowing of the cloth developed unevenly with exposure, not definitely vertically graded as might be expected (horizontal grading being ruled out because the specimen rack revolves about a vertical axis) but rather indiscriminately. The reasons for this selective yellowing are not known. In the second experiment, individual swatches were exposed in the orthodox manner.

The data presented in Table II indicate an increased resistance to wetting during the first few hours of exposure, followed by gradually increasing wettability with increasing exposure, roughly paralleling the bleaching and yellowing effect noted above. The odor of the exposed wool when wet, which became stronger with increasing exposure, may be described as a blend of the familiar empyreumatic odor obtained by burning wool and the odor of liquid stripping agents of the sodium or zinc sulfoxylate-formaldehyde type.

TABLE II. WETTING TIME OF WOOLEN CLOTH AS A FUNCTION OF THE DURATION OF FADEOMETER EXPOSURE

Fadeometer exposure (hrs.)	Wetting time (sec.): Median (mean of middle 3 of 5 determinations)		Greatest % variation from median		Mean of 2 medians	*s* from *st* = 4,500
	Set I	Set II	Set I	Set II		
0	610	1,733	27	51	1,172	—
1	973	2,622	24	47	1,798	4,500
4	762	1,152	28	13	957	1,125
9	969	710	35	36	840	500
16	581	354	41	21	468	281
25	444	251	44	15	348	180
36	266	113	44	45	190	125
49	101	67	25	137	84	92
64	70	50	69	54	60	70
81	65	47	40	72	56	56
100	66	43	42	44	55	45
121	35	31	23	113	33	37
144	27	10	70	40	19	31
169	10	7	50	29	9	27
196	11	7	36	29	9	23
225	18	7	56	14	13	20
256	3	6	266	17	5	18
289	6	4	167	75	5	16
324	5	4	40	50	5	14
361	5	4	60	50	5	12
400	4	3	125	33	4	11
		Mean	62	47		

TABLE III. ALKALI-SOLUBILITY OF FADEOMETER-EXPOSED SWATCHES

Fadeometer exposure (hrs.)	Alkali solubility	Fadeometer exposure (hrs.)	Alkali solubility
0	1.64	121	7.23
1	1.08	144	9.53
4	1.93	169	10.9
9	2.28	196	14.9
16	2.94	225	14.8
25	3.19	256	16.5
36	3.48	289	19.0
49	4.17	324	19.8
64	5.38	361	23.1
81	4.99	400	24.8
100	7.33		

TABLE IV. COLOR SPECIFICATIONS OF FADEOMETER-EXPOSED SWATCHES TREATED WITH LEAD ACETATE SOLUTION

Fadeometer exposure (hrs.)	Dominant wave length	Brightness	Purity
0	576	19	18
1	580	15	19
4	591	11	22
9	580	8	19
16	600	6	13
25	570	6	24
36	596	4	22
49	558	4	15
100	558	4	15
225	502	4	6
400	502	4	6

Set II shows evidence of more uniform exposure, but individual differences in wettability are still great.

The simplest approximate empirical equation to fit these data is

$$st = \text{a constant},$$

where s is the wetting time in seconds and t is the exposure time in hours.

For set I, the constant selected from the midpoint of the plotted curve is ($s = 100$, $t = 50$) or 5,000; for set II, ($s = 90$, $t = 45$) or 4,050. Thus a rough approximation to fit the mean of both sets of medians is:

$$st = 4{,}500.$$

While this equation fits the data very imperfectly it does not seem worth the effort to attempt corrections because of the variability of the data, the probable dependence of sinking time on fiber size, yarn size, fabric weight, and similar factors, and the unpredictable effect of the one-sidedness of the exposure.

Table III illustrates increasing alkali solubility with increasing exposure.

Results of the lead-acetate treatment of exposed swatches, which are given in Table IV, indicate increasing formation of lead sulfide with increasing exposure. The odor of exposed swatches when boiled in this test solution was similar to that in the wetting tests, but much stronger.

Conclusions

All the evidence obtained from the tests described corroborates the view that light exposure modifies the sulfur-containing groups of the wool fiber most, the chief one of which is the disulfide linkage of the cystine residue. There is a good correlation between the degree of modification and wettability.

There is some evidence supporting the theory that absorbed water hydrates the polar groups of proteins and polyuronides [5, 6]; thus the increase of polar groups in wool keratin caused by rupture of the cystine linkage might explain its increased wettability.

Acknowledgment

Thanks are extended to Paul D. Burnham, who first noticed the comparative ease of wetting of Fadeometer-exposed wool, and to Wilbert Carr, Jr., who suggested the empirical formula to fit the exposure-wetting time data.

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Phosphorylated Cotton Cellulose as a Cation-Exchange Material

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Abstract

It was found that phosphorylated cotton cellulose made by the phosphoric acid-urea method has a high cation-exchange capacity and when used in the form of a coarse fabric it shows good flow characteristics in the calcium-hydrogen cycle. Its cation-exchange capacity increases with increasing phosphorus content and at a phosphorus content of about 5 percent the cation-exchange capacity reaches about 1,000 milliequivalents per kilogram. It is possible that specialized uses may be found for phosphorylated cotton cellulose, especially in the fabric form.

A NUMBER of samples of phosphorylated cotton cellulose were available in connection with a project on the fireproofing of cotton fabrics. The product is apparently a stable, partially substituted cellulose phosphate containing free or partially neutralized acid groups. Since it seemed likely that this material would act as a cation exchanger, it was tested for cation-exchange capacity. Many of the samples showed capacities comparable to those obtained with commercial cation-exchange materials. Some preliminary work was done on samples phosphorylated with phosphorus oxychloride and pyridine. It was found, however, that better results could be obtained when the cotton cellulose was phosphorylated with phosphoric acid and urea, a method described by Coppick and Hall [2]. Cotton fabric was phosphorylated in this manner and found to be an effective cation-exchange material.

Preparation of Samples

Sample No. 1. Low-viscosity cotton linters, 100 g., were mixed with 1,000 ml. of pyridine and 170 ml. of phosphorus oxychloride. The mixture was refluxed in an oil bath held at 125–130°C for 3 hours, poured onto cracked ice, and the solid material was washed free from pyridine and placed in 2-percent acetic acid for 2 hours. It was then washed thoroughly and dried *in vacuo* at 105°C.

Sample No. 2. This sample was prepared in the same way as sample No. 1, but the solid material was washed with pyridine before it was placed on cracked ice.

Sample Nos. 3, 4, 5, and 6. Low-viscosity linters, 140 g., were mixed with 270 g. of urea, 173 g. of 85-percent phosphoric acid, and 417 g. of water at 90°C. After standing 30 minutes the material was put through a wringer to remove the excess solution and was dried at 60°C in a forced-draft oven. The dried material was divided into portions, heated in various ways, washed with boiling water, and dried. Heating times and temperatures for these samples are given in Table I.

Sample Nos. 7, 8, and 9. Low-viscosity linters, 100 g., were mixed with 180 g. of urea, 115 g. of 85-percent phosphoric acid, and 200 g. of water. After 30 minutes the material was put through a wringer. It now weighed 277 g. It was dried at 60°C in a forced-draft oven and divided into portions which were heated for the times and at the temperatures given in Table I. The samples were then washed with boiling water and dried.

Sample No. 10. Raw cotton fiber, 100 g., was impregnated with a solution containing 216 g. of urea, 138 g. of 85-percent phosphoric acid, and 240 g. of water. The cotton took up 333 g. of the solution. It was dried for 40 minutes at 60°C in a forced-draft oven and then heated at 160°C for 1 hour. The cotton was washed with water, boiled with water for ½ hour, washed again, and dried.

Sample No. 11. This sample was made in the same way as sample No. 10, but the cotton was mercerized with 17.5-percent sodium hydroxide prior to

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TABLE I. CATION-EXCHANGE CAPACITY AND PHOSPHORUS CONTENT OF PHOSPHORYLATED COTTON CELLULOSE PREPARED BY VARIOUS METHODS

Sample No.	Material and method of preparation	Phosphorus content (%)*	Cation-exchange capacity m.e./kg.*
1	Cotton linters, $POCl_3$-pyridine	10.1	800
2	Cotton linters, $POCl_3$-pyridine	8.6	810
3	Cotton linters, H_3PO_4-urea, 140°, ½ hr.	3.3	600
4	Cotton linters, H_3PO_4-urea, 140°, 1 hr.	4.2	830
5	Cotton linters, H_3PO_4-urea, 160°, ½ hr.	4.4	860
6	Cotton linters, H_3PO_4-urea, 160°, 1 hr.	4.2	810
7	Cotton linters, H_3PO_4-urea, 140°, ½ hr.	2.9	610
8	Cotton linters, H_3PO_4-urea, 160°, 1 hr.	6.1	1,100
9	Cotton linters, H_3PO_4-urea, 160°, 1 hr.	7.3	1,210
10	Cotton fiber, H_3PO_4-urea, 160°, 1 hr.	4.1	960
11	Cotton fiber, H_3PO_4-urea, 160°, 1 hr.	5.5	1,270
12	Cotton fabric, H_3PO_4-urea, 149°, ¼ hr.	4.6	870
13	Cotton fabric, H_3PO_4-urea, 149°, ¼ hr.	2.8	790
—	Carbonaceous zeolite, commercial	—	870
—	Cation-exchange resin, commercial	—	960

* Air-equilibrated basis, moisture content approximately 5 to 6 percent.

treatment. The take-up of the phosphorylating solution was 270 g. per 100 g. of cotton.

Sample No. 12. A kier-boiled, bleached broadcloth with a thread count of 100 by 60 threads per inch was wetted with a solution containing 49.6 percent of urea, 18.4 percent of phosphoric acid, and 32 percent of water. The excess solution was squeezed out in a wringer and the fabric was heated in a forced-draft oven for 15 minutes at 149°C. It was then washed thoroughly and dried.

Sample No. 13. This sample was prepared in the same way as sample No. 12, but the material used was a very coarse, kier-boiled fabric with a burlap-like weave and a thread count of 12 by 7 threads per inch.

Methods of Measuring Cation-Exchange Capacity

Most of the measurements of cation-exchange capacity were made by determining the acid produced when the phosphorylated cotton cellulose in the acid form was mixed with a dilute solution of calcium chloride. A sample weighing 0.500 g. was placed in a small fritted glass funnel and put into the acid form by passing 50 ml. of 5-percent hydrochloric acid through it. The material was then washed with water until 50 ml. of the filtrate plus one drop 0.1*N* sodium hydroxide gave a pink color with phenolphthalein. The cotton was transferred to a stoppered flask and 100 ml. of 0.01*N* calcium chloride were added. After remaining for 30 minutes, with frequent shaking, the mixture was filtered and the cotton was washed with water. The entire filtrate was titrated with 0.1*N* sodium hydroxide solution. The number of ml. of solution used was multiplied by 200 to obtain the cation-exchange capacity in milliequivalents per kilogram. All values reported in this paper are on air-equilibrated samples. Moisture determinations were made on all samples, but are not reported since they were in the range of 5 to 6 percent and are considered sufficiently constant.

Values obtained by the above static method on many of the samples were verified by aliquoting the effluents and making a soap titration to determine the residual hardness. The two sets of values were in agreement. It is realized that this static method, which involves only one concentration of calcium chloride, may not give quite the maximum exchange capacity of the material. It does, however, agree reasonably well with the column method and is believed to be adequate for comparative purposes.

Some of the larger samples were evaluated by the method of the American Water Works Association [1]. In this method a cation-exchange column of 26-mm. internal diameter was used. The synthetic test water containing calcium chloride and magnesium sulfate had a hardness of 350 parts per million calculated as calcium carbonate. Runs were made in the calcium-hydrogen cycle and in the calcium-sodium cycle. The volume of water softened and the point of break-through were determined by soap titrations. Results were calculated to give the cation-exchange values in milliequivalents per kilogram.

Experimental Results and Discussion

The cation-exchange capacities of the preparations of cotton cellulose, phosphorylated in various ways, are shown in Table I. All values given in this table were obtained by the static method. It will be noted that even at a lower phosphorus content the cation-exchange capacity of samples phosphorylated by the phosphoric acid-urea method was much greater than the cation-exchange capacity of samples prepared by the phosphorus oxychloride-pyridine method. With samples phosphorylated by the phosphoric acid-urea method, the cation-exchange capacity varies almost directly with the phosphorus content. Table I also shows that phosphorylated cotton cellulose compares favorably in capacity with commercial cation-exchange materials.

Some of the samples were tested by the method of the American Water Works Association [1]. Sample No. 11 was tested in the calcium-sodium cycle and also in the calcium-hydrogen cycle. The amount needed to fill the tube to the 48-cm. level was 58 g., volume 260 ml. This sample's initial capacity was 1,400 milliequivalents per kg., but this fell to 970 on the second cycle. After 6 runs in the calcium-sodium cycle the material was tested for 4 runs in the calcium-hydrogen cycle and an exchange capacity of about 1,000 was obtained. It was put back on the calcium-sodium cycle for one more run and an exchange capacity of 1,090 was obtained. At this point the material had been in the tube for 4 months. The flow rate was now so slow that the run was discontinued. Throughout this experiment the flow rate was slow, starting at about 1 liter every 1.5 hours.

In another experiment with sample No. 11 only 30 g. were used. This provided a 24-cm. column in the tube. This sample was tested in the calcium-hydrogen cycle. The initial capacity was 1,200 milliequivalents per kg. This fell slowly to 1,000 at the sixteenth run, to 900 at about the thirtieth run, and to 800 at the sixty-fifth run. At this point the material had been in the tube for 5 months. The rate of flow was slow throughout the experiment and never more than 1 liter per hour. At the sixty-fifth run the flow rate was 0.25 liter per hour.

Since the flow rate through phosphorylated cotton fiber was so slow, phosphorylated cotton cloth was tried. Sample No. 12, a closely woven broadcloth, was cut into discs that exactly fitted the tube. A 25-cm. column of these discs weighing 67 g. was used. The flow rate was very slow, but an exchange capacity of 730 was obtained in the calcium-hydrogen cycle. The discs were removed from the tube, cut into small pieces, and these were packed at random in the tube. The flow rate was now much improved—about 1.5 liter per hour. The exchange capacity remained at 730 milliequivalents per kg.

Discs cut from sample No. 13, a coarse bagging material, were then tried. A 38-cm. column of 240 of these discs weighing 61 g. was used. In the calcium-hydrogen cycle the flow rate was 1 liter per hour for the first cycle, 1.7 liters per hour for the second cycle, and 3.2 liters per hour for the third cycle. Exchange capacities were 630, 570, and 520 milliequivalents per kg., respectively. At this point a run in the calcium-sodium cycle was made. The exchange capacity was 520, but the flow rate was now only 0.6 liter per hour. Returning the material to the calcium-hydrogen cycle did not improve this flow rate. It would appear that better flow rates are obtained with phosphorylated cotton in the calcium-hydrogen cycle than in the calcium-sodium cycle.

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Discussion of Published Papers

"Use of Supersonics in the Preparation of Fiber Samples for Electron-Microscope Studies"*

Comments by A. Engeler†

In this department from time to time are published discussions of papers which have appeared in previous issues of this publication. These are presented in the belief that such discussion will result in bringing out additional information with respect to a given subject. The JOURNAL *welcomes comments concerning papers which it publishes. When possible, additional data from the correspondent's research should be incorporated. The editors of course reserve the right to decide whether comments will or will not be published in this department.*

THE development and first application in Switzerland of the use of supersonic waves for investigation of the fine structure of textile fibers was at the Laboratoire fédéral d'essai des matériaux et Institut de recherches (Physical Laboratory of the Swiss Federal Laboratory for Testing Materials and Research), St. Gallen. The first results of our supersonic investigations of textile fibers were published in February, 1946, in *Experientia* **2**, No. 3, 105–107, under the title "Elektronenmikroskopische Untersuchungen an Zellulosefasern nach Behandlung mit Ultraschall." The authors of the review, published in TEXTILE RESEARCH JOURNAL,* were not precisely informed in all the details of the experimental procedure, the evaluation of the results, and the apparatus. Consequently, certain technical details are not entirely complete and correct.

The use of supersonics for the disintegration of fiber samples was developed in connection with an investigation of the internal fibro-structure and the arrangement of structural elements in various fiber samples, and not for the purpose of preparing samples for observation in the electron microscope. The electron micrographs were only an incidental expedient, and an additional help where the magnification of the optical microscope did not suffice.

The preparation of the fibers and their treatment with supersonics was at the above-mentioned Swiss Federal Laboratory, and not at the Institute of Plant Physiology as stated in the article in TEXTILE RESEARCH JOURNAL. For the electron micrographs we are indebted to Mr. K. Mühlethaler, who produced them by means of the electron microscope developed by, and belonging to, Messrs. Trüb, Täuber & Co.

The vibrator used was not the apparatus made by Biennophone, Bienne. An ultrasonic apparatus, furnished by Hofrela Inc., Grenchen, Switzerland, is in use at our Laboratory.

It is planned to render a complete report as to the effect of the impact of supersonic waves on different types of fiber samples as soon as studies now under way are completed.

* Title of a paper by A. Frey-Wyssling and K. Mühlethaler, which appeared in the January, 1947, issue of TEXTILE RESEARCH JOURNAL, page 32.

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Book Reviews

Fatty Acids, Their Chemistry and Physical Properties. Klare S. Markley. (Monographs on the chemistry and technology of fats, oils, and related substances.) New York, Interscience Publishers, Inc., 1947. 668 + x pages. Price, $10.00.

(Reviewed by Gregg Dougherty, Princeton University)

Because of their wide occurrrence in nature, the fatty acids attracted the attention of chemists at an early date—near the beginning of the nineteenth century—and the interest in this family of compounds has continued ever since. As a result much information, widely scattered in books and journals, has accumulated. This monograph is the first serious attempt to organize the material and present it in a systematic way. The author has been quite successful.

A few pages are devoted to a discussion of the history and nature of fats and waxes, about 65 pages to classification and structure, and the bulk of the book is concerned with the physical properties, the reactions, the synthesis, and the isolation and identification of fatty acids. There is an admitted preoccupation with the higher acids closely related to the natural fats, oils, and waxes. One might complain that in a book with this title too little attention has been paid to the lower members of the series.

The account of the physical properties and the methods by which the measurements are made is very satisfactory. The text is liberally illustrated with graphs and tables which show clearly the relationships between physical properties and structure. The chapters on chemical reactions are also well done although here again one gets the impression that the author's most intimate knowledge and greatest interest are concerned with the chemistry of fats and oils. In a book of this size one would expect to find a little more detail than is actually given on such subjects as *a*-amino acids and the sulfur derivatives of aliphatic acids. The section on synthesis covers the more orthodox methods for the preparation of the saturated acids, their hydroxy, keto, and unsaturated derivatives. In addition there is an interesting account of the methods whereby fatty acids are obtained from hydrocarbons, and a discussion of the theories advanced to explain the appearance of acids in biosynthetic processes. For the general worker in organic chemistry, the section on isolation and identification should be particularly useful. Collected here are the important methods which are scattered and often difficult to find in periodicals and in books covering the general subject.

As a whole, the book is clearly written, is well indexed, and constitutes a distinguished contribution to the literature of special subjects in organic chemistry.

Flameproofing Textile Fabrics. Edited .by Robert W. Little. New York, Reinhold Publishing Corp., 1947. 430 pages. Price, $6.75.

(Reviewed by F. Bonnet, American Viscose Corporation)

This book, which is one of the American Chemical Society's Monograph series, is most timely in its appearance in that it supplies much factual data concerning the burning of cellulosic fabrics and describes the various methods for flameproofing them.

California has made it illegal to sell or offer for sale fabrics or garments which ignite and burn so readily that they constitute a grave danger. The passing of the California law, decisions of the courts, and the general publicity incident to burning accidents, such as the Cocoanut Grove fire in Boston and the various hotel fires following the Boston catastrophe, have focused attention upon a serious fire hazard due to flammable textiles.

At the outbreak of the war the need for flameproofing equipment for the armed services was vital and a great deal of work on the problem was done in the various government laboratories. The information gathered by these laboratories has now been released for public information in this book.

Dr. R. W. Little and his coeditors have compressed the essentially important material within the confines of this book, in which they have been aided by more than a dozen other specialists, all of whom have done some work on the flammability of fabrics or on the problem of rendering cellulosic materials flameproof.

The book is divided into three sections. The first comprises the fundamentals of burning and the mechanism of flameproofing; the second deals with methods of test and evaluation; and the third is concerned with the applications of flameproofing cotton fabrics for army clothing, for military equipage, and for civilian fabrics.

Flameproofing of Textile Fabrics will be of particular interest to those branches of the textile industry which are manufacturing, finishing, or converting fabrics which must meet certain specifications with respect to flammability.

Textile Microscopy in Germany. Textile Series, Report No. 13. Office of The Quartermaster General "Textile Team." New York, Textile Research Institute, Inc., 1947. 147 pages. Price, $5.50.

(Reviewed by G. L. Royer, American Cyanamid Company)

Several reports and many photomicrographs obtained by the "Textile Team" in Germany have been assembled in this book. A paper reprinted from the TEXTILE RESEARCH JOURNAL of February, 1947, by H. Reumuth of the I. G. Micro-Laboratory in Höchst, describes, along with excellent photomicrographs, the use of phase microscopy in studying textile fiber structure. The work was done with Carl Zeiss equipment developed in Germany at the start of the war. A short bibliography of publications on microscopy published in Germany during the war has also been prepared by H. Reumuth.

This is followed by a large number of photomicrographs of textile fibers catalogued by Werner von Bergen, Technical Intelligence Investigator in Germany, for the Office of The Quartermaster General, from material prepared by H. Reumuth. These are longitudinal views of the common textile fibers and some special views of fibers which have received specific treatments. Also included from the I. G. Farben Laboratories at Höchst is a group of photomicrographs showing cross-sectional and longitudinal views together with physical data and x-ray diffraction patterns for a number of synthetic fibers. From the Zellwolle-Lehrspinnerei at Denkendorf the "Textile Team" obtained a complete atlas of photomicrographs of nearly all the known textile fibers showing both cross-sectional and longitudinal views and the entire group of 82 is reproduced. Section VII of this book includes the photomicrographs and an analysis of the fiber properties of a large number of samples most of which were brought back by the "Synthetic Fiber Textile Team." This work was done in several industrial laboratories in this country.

An appendix includes selected electron micrographs prepared in the United States and Holland during various studies on fiber structure. Some very excellent micrographs of wool, cotton, ramie, and chemical wood pulp represent work from American laboratories, and a paper reprinted from TEXTILE RESEARCH JOURNAL for November, 1946, shows the work of P. H. Hermans of Holland on cellulose fibers ground in water.

The information assembled in this book will be of value to anyone using the microscope to identify textile fibers. It also presents some of the latest information on fiber structure obtained by the optical, the phase, and the electron microscopes which should be of interest to workers in fiber research and to users of textile fibers. Other fiber data which are included should also be of value.

Colloid Science. A Symposium. Contributors: E. K. Rideal, A. E. Alexander, D. D. Eley, P. Johnson, F. Eirich, R. F. Tucket, J. H. Schulman, M. P. Perutz, G. S. Adair, G. B. B. M. Sutherland and R. R. Smith. Brooklyn, Chemical Publishing Co., Inc., 1947. 208 + x pages. Price, $6.00.

(Reviewed by Earl K. Fischer, Institute of Textile Technology, Charlottesville, Virginia)

This small volume contains the substance of lectures given in a course in colloids at Cambridge University. The topics discussed cover the whole field of colloidal phenomena: adsorption, surface films, foams, emulsions, membrane equilibria, polymerization, and properties of polymer solutions. It is inevitable, with such a diversity of subject matter, that the treatment is necessarily brief; indeed, some of the papers appear to be little more than revised lecture notes. The authors include critical comments, however, and many of the papers contain suggestions for research. The book is quite readable and will be of value chiefly to those requiring concise reviews of certain topics of current interest.

ABSTRACTS

SERVICES AVAILABLE

Reprints of the original articles abstracted in TEXTILE RESEARCH JOURNAL *are often available from the publishers. Otherwise, it may be possible to secure copies of the periodicals. Orders should be sent direct to the publishers.*

Photostat negatives of articles abstracted will be furnished to members of the Institute at a cost of 25 cents per page for pages not exceeding 7 inches in width and 35 cents per page for larger sizes up to 11½ x 14 inches. Photostats of patents are 35 cents per page. Postage will be added.

Microfilm copies and paper enlargements of microfilm may be obtained from: Microfilms Inc., 313 N. First St., Ann Arbor, Mich.; New York Public Library, New York, N. Y.; Yale University Library, New Haven, Conn.; Harvard University Library, Cambridge, Mass.; and Library of Congress, Washington, D. C. Translations may also be obtained from the above sources.

The JOURNAL *is again offering to its subscribers reprints of the Abstracts and Book Reviews sections, printed on one side of the sheet so that the items may be clipped, pasted on cards, and filed for permanent reference. Subscriptions to this service for 1948 are $3.00 each. Orders for this special service should be mailed at once to Textile Research Institute, Inc., 10 East 40th Street, New York 16, N. Y.*

A list of periodicals, the abbreviations used in references to articles, and the addresses of publishers of English language publications is given below.

List of Periodicals Abstracted *

American

Name and Address of Journal	*Customary Abbreviation*
American Dyestuff Reporter 1 Madison Ave., New York 10, N. Y.	Am. Dyestuff Reptr.
American Journal of Physics American Inst. of Physics, 57 E. 55th St., New York 22, N. Y.	Am. J. Phys.
American Journal of Science New Haven, Conn.	Am. J. Sci.
American Society for Testing Materials Bulletin 1916 Race St., Philadelphia 3, Pa.	ASTM Bull.
American Wool and Cotton Reporter 530 Atlantic Ave., Boston 10, Mass.	Am. Wool and Cotton Reptr.
Analytical Chemistry (formerly "Ind. Eng. Chem., Anal. Ed.") American Chemical Society 1155 16th St., N.W., Washington 6, D. C.	Anal. Chem.
Bell System Technical Journal American Telephone and Telegraph Co. 195 Broadway, New York 7, N. Y.	Bell System Tech. J.
Bibliography of Scientific and Industrial Reports U. S. Department of Commerce, Office of Technical Services Washington 25, D. C.	Bib. Sci. and Ind. Reports
Bulletin of the Lowell Textile Institute Lowell, Mass.	Bull. Lowell Tex. Inst.

* Included in the list are also some of the publications which are frequently referred to in papers originally published in this journal.

Name and Address of Journal	*Customary Abbreviation*
Calco Technical Bulletin American Cyanamid Co., Calco Chemical Div., Bound Brook, N. J.	Calco Tech. Bull.
Chemical Abstracts Ohio State University, Columbus 10, Ohio	Chem. Abstr.
Chemical Engineering with Chemical & Metallurgical Engineering 330 W. 42nd St., New York 18, N. Y.	Chem. Eng.
Chemical and Engineering News 1155 16th St., N.W., Washington 6, D. C.	Chem. and Eng. News
Chemical Industries 522 Fifth Ave., New York 18, N. Y.	Chemical Industries
Chemical Reviews Mt. Royal and Guilford Aves., Baltimore 2, Md.	Chem. Revs.
Chemist-Analyst J. T. Baker Chemical Co., Phillipsburg, N. J.	Chemist-Analyst
Chemurgic Digest 1368 N. High St., Columbus 1, Ohio	Chemurgic Digest
Chronica Botanica (The International Plant Science News Magazine) Chronica Botanica Co., P.O. Box 151, Waltham, Mass.	Chronica Botan.
Cord Age Magazine 468 4th Ave., New York 16, N. Y.	Cord Age Mag.
Electronic Industries & Electronic Instrumentation 480 Lexington Ave., New York 17, N. Y.	Electronic Inds. & Electronic Instrumentation
Electronics 330 W. 42nd St., New York 18, N. Y.	Electronics
Fibre and Fabric Wade Publishing Co., 465 Main St., Cambridge 42, Mass.	Fibre and Fabric
Foreign Commerce Weekly Supt. of Documents, Government Printing Office Washington 25, D. C.	Foreign Com. Weekly
India Rubber World 386 Fourth Ave., New York 16, N. Y.	India Rubber World
Industrial and Engineering Chemistry 1155 16th St., N.W., Washington 6, D. C.	Ind. Eng. Chem.
Interchemical Review 432 W. 45th St., New York 19, N. Y.	Interchem. Rev.
Journal of Agricultural Research Supt. of Documents, Government Printing Office Washington 25, D. C.	J. Agr. Research
Journal of the American Chemical Society 1155 16th St., N.W., Washington 6, D. C.	J. Am. Chem. Soc.
Journal of the American Leather Chemists' Association Dept. of Leather Research, Univ. of Cincinnati, Cincinnati 21, Ohio	J. Am. Leather Chemists' Assoc.
Journal of the American Oil Chemists' Society (formerly "Oil and Soap") 35 E. Wacker Drive, Chicago 1, Ill.	J. Am. Oil Chemists' Soc.

Name and Address of Journal	*Customary Abbreviation*
Journal of the American Society of Agronomy Agr. Expt. Sta., Morgantown, W. Va.	J. Am. Soc. Agron.
Journal of Applied Physics 57 E. 55th St., New York 22, N. Y.	J. Applied Phys.
Journal of Biological Chemistry Mt. Royal and Guilford Aves., Baltimore 2, Md.	J. Biol. Chem.
Journal of Chemical Education 20th and Northampton Sts., Easton, Pa.	J. Chem. Education
Journal of Chemical Physics 57 E. 55th St., New York 22, N. Y.	J. Chem. Phys.
Journal of Colloid Science Academic Press, Inc., 125 E. 23rd St., New York 10, N. Y.	J. Colloid Sci.
Journal of the Franklin Institute Prince and Lemon Sts., Lancaster, Pa.	J. Franklin Inst.
Journal of the Optical Society of America American Inst. of Physics, 57 E. 55th St., New York 22, N. Y.	J. Optical Soc. Am.
Journal of Organic Chemistry Mt. Royal and Guilford Aves., Baltimore 2, Md.	J. Org. Chem.
Journal of Physical & Colloid Chemistry Mt. Royal and Guilford Aves., Baltimore 2, Md.	J. Phys. & Colloid Chem.
Journal of Polymer Science Interscience Publishers, Inc. 215 4th Ave., New York 3, N. Y.	J. Polymer Sci.
Journal of Research of the National Bureau of Standards Supt. of Documents, Government Printing Office Washington 25, D. C.	J. Research Natl. Bur. Standards
Mechanical Engineering The American Society of Mechanical Engineers 29 W. 39th St., New York 18, N. Y.	Mech. Eng.
Modern Plastics 122 E. 42nd St., New York 17, N. Y.	Modern Plastics
Pacific Plastics 124 W. 4th St., Los Angeles 13, Calif.	Pacific Plastics
Paper Trade Journal 15 W. 47th St., New York 19, N. Y.	Paper Trade J.
Papers of the American Association of Textile Technologists Daily Trade Record Co., 8 East 13th St., New York 3, N. Y.	Papers of AATT
Physical Review American Inst. of Physics, 57 E. 55th St., New York 22, N. Y.	Phys. Rev.
Plastics (Chicago) Ziff-Davis Publishing Co., 185 N. Wabash Ave., Chicago 1, Ill.	Plastics (Chicago)
Plastics and Resins 299 Madison Ave., New York 17, N. Y.	Plastics and Resins
Rayon Organon Textile Economics Bureau, Inc. 10 E. 40th St., New York 16, N. Y.	Rayon Organon

Name and Address of Journal	*Customary Abbreviation*
Rayon Textile Monthly 303 5th Ave., New York 16, N. Y.	Rayon Text. Mo.
Review of Scientific Instruments 57 E. 55th St., New York 22, N. Y.	Rev. Sci. Instruments
Reviews of Modern Physics 57 E. 55th St., New York 22, N. Y.	Revs. Modern Phys.
Rubber Age 250 W. 57th St., New York 19, N. Y.	Rubber Age (New York)
Rubber Chemistry and Technology 1012 Second National Bank Building, Akron 8, Ohio	Rubber Chem. Technol.
Saco-Lowell Bulletin, Saco-Lowell Shops 60 Batterymarch St., Boston, Mass.	Saco-Lowell Bull.
Science The Science Press, Lancaster, Pa.	Science
Soap and Sanitary Chemicals 254 W. 31st St., New York 1, N. Y.	Soap Sanit. Chemicals
Synthetic Organic Chemicals Eastman Kodak Co., Rochester 4, N. Y.	Synthetic Org. Chemicals
Textile Age 381 4th Ave., New York 16, N. Y.	Textile Age
Textile Bulletin Clark Publishing Co., P. O. Box 1225, Charlotte 1, N. C.	Textile Bulletin
Textile Colorist and Converter 1 Madison Ave., New York 10, N. Y.	Text. Col. and Converter
Textile Industries (formerly "Cotton") W. R. C. Smith Publishing Co., Grant Bldg., Atlanta, Ga.	Textile Inds.
Textile World 330 W. 42nd St., New York 18, N. Y.	Textile World

British Empire

Biochemical Journal Cambridge University Press, Bentley House, 200 Euston Rd., London N.W. 1, England, or University of Chicago Press, 5750 Ellis Ave., Chicago 37, Ill.	Biochem. J.
British Plastics Dorset House, Stamford St., London S.E. 1, England	Brit. Plastics
Canadian Chemistry and Process Industries 137 Wellington St. W., Toronto 1, Ont.	Can. Chem. and Proc. Inds.
Canadian Journal of Research National Research Council, Ottawa, Canada	Can. J. Research
Canadian Textile Journal 1434 St. Catherine St. W., Montreal, Quebec, Canada	Can. Text. J.
Chemistry & Industry 56 Victoria St., London S.W. 1, England	Chemistry & Industry

Name and Address of Journal	*Customary Abbreviation*
Current Science Indian Institute of Science, Malleswaram P. O., Bangalore, India	Current Science
Dyer, Textile Printer, Bleacher and Finisher Heywood & Co., Ltd., Drury House, Russell St., Drury Lane, London W.C. 2, England	Dyer
Fibres 17 Stratford Place, London W. 1, England, or F. W. Faxon Co., 83 Francis St., Back Bay, Boston 15, Mass.	Fibres
Forecast (formerly "Synthetics and By-Products") Leonard Hill Ltd., 17 Stratford Place, London W. 1, England	Forecast
Indian Journal of Physics and Proceedings of the Indian Association for the Cultivation of Science Indian Assoc. for the Cultivation of Science 210 Bowbazar St., Calcutta, India	Indian J. Phys.
Indian Textile Journal Surya Mahal Military Square, Fort, Bombay, India	Indian Text. J.
Journal of the Chemical Society Burlington House, London W. 1, England	J. Chem. Soc.
Journal of the Council for Scientific and Industrial Research 314 Albert St., E. Melbourne, Victoria, Australia	J. Council Sci. Ind. Research
Journal of the Indian Chemical Society 92 Upper Circular Rd., Calcutta, India	J. Indian Chem. Soc. J. Indian Chem. Soc., Ind. & News Ed.
Journal and Proceedings of the Institution of Chemists (India) Honorary Asst. Secretaries, Chemical Dept., Medical College, Calcutta, India	J. Proc. Inst. Chemists (India)
Journal of Scientific and Industrial Research (India) Council of Scientific and Industrial Research The Mall, Civil Lines, Delhi, India	J. Sci. and Ind. Research (India)
Journal of Scientific Instruments Institute of Physics, 19 Albemarle St., London W. 1, England	J. Sci. Instruments
Journal of the Society of Chemical Industry (London) 56 Victoria St., London S.W. 1, England	J. Soc. Chem. Ind. (London)
Journal of the Society of Dyers and Colourists The University, Leeds, England	J. Soc. Dyers and Colourists
Journal of the Textile Institute 16 St. Mary's Parsonage, Manchester 3, England	J. Text. Inst.
Manual of the Textile Industry of Canada Canadian Textile Journal Publishing Co., Ltd. 1434 St. Catherine St., W., Montreal, P. Q., Canada	Manual Textile Ind. Can.
Nature Macmillan & Co., Ltd., St. Martin's St., London W. C. 2, England	Nature
New Zealand Journal of Science and Technology Government Printer, Wellington, N. Z.	New Zealand J. Sci. and Technol.
Paint Manufacture Leonard Hill Ltd., 17 Stratford Place, London W. 1, England	Paint Manuf.
Physics Abstracts Inst. of Electrical Engineers, Savoy Place, Victoria Embankment, London W.C. 2, England	Phys. Abstr.

Name and Address of Journal	*Customary Abbreviation*
Proceedings of the Physical Society (London) 1 Lowther Gardens, London S.W. 7, England	Proc. Phys. Soc. (London)
Proceedings of the Royal Society (London) Cambridge University Press, 200 Euston Rd., London N.W. 1, England	Proc. Roy. Soc. (London)
Pulp & Paper Magazine of Canada National Business Publications, Ltd., Gardenvale, Quebec, P. Q., Canada	Pulp & Paper Mag. Can.
Silk and Rayon St. James House, 44 Brazennose St., Manchester 2, England	Silk and Rayon
Silk Journal & Rayon World Old Colony House, S. King St., Manchester 2, England	Silk J. & Rayon World
Textile Journal of Australia 19–47 Jeffcott St., Melbourne, Victoria, Australia	Text. J. Australia
Textile Manufacturer 31 King St., West, 3, Manchester, England	Textile Manufacturer
Textile Mercury and Argus 41 Spring Gardens, Manchester, England	Text. Mercury and Argus
Textile Recorder Old Colony House, S. King St., Manchester 2, England	Textile Recorder
Textile Weekly 33 Blackfriars St., Manchester 3, England	Textile Weekly
Transactions of the Faraday Society Gurney and Jackson, 98 Great Russell St., London, England	Trans. Faraday Soc.

French

Annales de chimie	Ann. chim.
Bulletin de la société chimique de France	Bull. soc. chim. France
Chimie & industrie	Chimie & industrie
Comptes rendus hebdomadaires des séances de l'académie des sciences	Compt. rend.
Industries des plastiques	Inds. plastiques
Industrie textile	Ind. textile
Journal de chimie physique et de physico-chimie biologique	J. chim. phys.
Teintex	Teintex

German

Allgemeine Textil-Zeitschrift	Allgem. Textil-Z.
Angewandte Chemie	Angew. Chem.
Berichte der deutschen chemischen Gesellschaft	Ber.
Cellulosechemie	Cellulosechemie
Chemisches Zentralblatt	Chem. Zentr.
Collegium	Collegium
Deutsche Färber-Zeitung	Deut. Färber-Ztg.

Name of Journal	*Customary Abbreviation*
Miscellaneous Foreign	
Industria y química (Buenos Aires) (Argentinian)	Industria y química (Buenos Aires)
Tidsskrift for Textilteknik (Danish)	Tids. Textilteknik
Chemisch Weekblad (Dutch)	Chem. Weekblad
Recueil des travaux chimiques des Pays-Bas (Dutch) (In English, French, or German)	Rec. trav. chim.
Fibres, Fabrics & Cordage (Irish)	Fibres, Fabrics & Cordage
Anales de física y química (Madrid) (Spanish)	Anales fís. y quím. (Madrid)

Name of Journal	*Customary Abbreviation*
Journal für makromolekulare Chemie	J. makromol. Chem.
Kolloid-Zeitschrift	Kolloid-Z.
Melliand Textilberichte	Melliand Textilber.
Naturwissenschaften	Naturwissenschaften
Planta	Planta
Spinner und Weber	Spinner u. Weber
Textil-Praxis	Textil-Praxis
Wasser und Abwasser	Wasser u. Abwasser
Zeitschrift für Elektrochemie und angewandte physikalische Chemie	Z. Elektrochem.
Zeitschrift für physikalische Chemie	Z. physik. Chem.
Zeltschrift des Vereines deutscher Ingenieure im NSBDT	Z. Ver. deut. Ing.
Zellwolle und Kunstseide	Zellwolle u. Kunstseide
Japanese	
Bulletin of the Chemical Society of Japan	Bull. Chem. Soc. Japan
Journal of the Agricultural Chemical Society of Japan	J. Agr. Chem. Soc. Japan
Journal of the Chemical Society of Japan	J. Chem. Soc. Japan
Russian	
Bulletin de l'académie des sciences de l'Union des Républiques Soviétiques Socialistes	Bull. acad. sci. URSS
Comptes rendus (Doklady) de l'académie des sciences de l'U.R.S.S. (In English, French or German)	Compt. rend. acad. sci. U.R.S.S.
Journal of Applied Chemistry (USSR)	J. Applied Chem. (U.S.S.R.)
Legkaya Promyshlennost (Light Industry)	Legkaya Prom.
Trudy Konferentsii po Vysokomolekulyarnym Soedineniyam	Trudy Konferents. Vysokomolekulyar. Soedineniyam
Swedish	
Svensk Kemisk Tidskrift	Svensk Kem. Tid.
Svensk Papperstidning	Svensk Papperstidn.
Teknisk Tidskrift	Tek. Tid.
Swiss	
Experientia	Experientia
Helvetica Chimica Acta (In French, German, or Italian)	Helv. Chim. Acta
Schweizer Archiv für angewandte Wissenschaft und Technik	Schweiz. Arch. angew. Wiss. u. Tech.
Textil-Rundschau	Textil-Rundschau

into 2 solutions, neither of which is especially hygroscopic but which, when mixed together, react rapidly with water. The 1st solution is prepared by bubbling 60 g. SO_2 into a mixture of 300 ml. MeOH (containing 0.02% H_2O) and 300 ml. pyridine; the 2nd solution contains 30 g. iodine/l. Details are given of the determination of H_2O in various samples of pulp and rayon; it is applicable to MeOH, EtOH, sugar solutions, tall-oil products, and similar substances. For dark-colored liquors, such as black liquor, in which the color change with excess iodine cannot be observed, a titration with Pt electrodes is used.

Text. Research J. Jan. 1948

Phase-Contrast Microscopy

The control of amplitude in phase-contrast microscopy. E. W. Taylor. *Proc. Roy. Soc.* **A190**, 422–5 (Aug. 12, 1947).

The usual phase-contrast method frequently leads to considerable difference in amplitude between the light which has passed through the object and that which has not, thus masking the contrast sought. This new method permits control of amplitude of both direct and indirect beams by addition of the following features: a plane-polarized light source is used, and just below the usual annular phase-plate is placed another annulus, part of which consists of right-handed quartz and the rest of left-handed quartz, so arranged that the direct and indirect beams are rotated in opposite directions. An ordinary rotatable analyzer placed between the phase-plate and the eye then makes it possible to obtain any desired ratio of intensity between direct and indirect beams.

Text. Research J. Jan. 1948 W. E. Davis

Moisture in Fibers

A calorimetric investigation of moisture in textile fibers. Frank C. Magne, H. J. Portas, and Helmut Wakeham. *J. Am. Chem. Soc.* **69**, 1896–902 (Aug. 1947).

A calorimeter using the method of mixtures is described. It has been used for the study of the amounts of freezing and nonfreezing water in samples of native cottons, mercerized cotton, Cordura rayon, nylon, and glass fibers, all in yarn form at −4.5°C and lower temperatures, and with various moisture contents between 4% and 80%. The amount of freezing and nonfreezing water for each fiber-moisture content was calculated. The results are discussed and interpreted as indicating a means of differentiation between water of primary adsorption and water adsorbed in multilayer formation or by capillary condensation in cellulosic fibers. From the data obtained, estimates of the degree of crystallinity and capillary volumes within certain limiting radii were made for the cotton and rayon fibers. The data indicate that there is much less nonfreezing water in nylon than in cellulosic fibers and none in glass.

A. R. Macormac

Text. Research J. Jan. 1948

Moisture Determination

New electric method for determining moisture content. J. Boeke. *Philips Tech. Rev.* **9**, 13–15 (1947) (through *Chem. Abstr.* **41**, 5414*f* (Sept. 10, 1947)).

The method is applicable to the determination of H_2O in liquid or solids. The H_2O is extracted with a solution of 10% oxalic acid in acetone. The increase in conductivity is a function of the amount of H_2O taken up. The substance to be tested is kept in intimate contact with the acetone solution for about 2 hrs. The apparatus is inexpensive and simple in operation; all parts of the apparatus are made of glass or porcelain except the electrodes, which are of Pt, such as are used in standard conductivity cells. Calibration curves are shown.

Text. Research J. Jan. 1948

Fiber Orientation in Paper

Determination of fiber orientation in paper. Ragnar Danielsen and Börje Steenberg. *Svensk Papperstidn.* **50**, 301–5 (1947) (in English) (through *Chem. Abstr.* **41**, 7116*h* (Nov. 10, 1947)).

In the determination of fiber orientation in paper, it is best to use papers containing less than 1% of fibers marked by an ordinary dye or rendered fluorescent. An instrument is described for determining the orientation of the fibers, and the method of plotting the results is given. The orientation in the machine direction is very marked on the wire side but distinctly less so on the felt side. Thus, the effect of the slice on orientation seems to be very small. Under certain conditions wire shake increases the machine alignment of fibers. Practically the same fiber-distribution diagram is shown by papers made on two different machines.

Text. Research J. Jan. 1948

pH Measurement

Acids, bases, salts—pH. C. Ross Bloomquist. *Interchem. Rev.* **6**, 31–48 (Summer, 1947).

A review of the principles of pH measurement by indicator and electrometric methods, buffers, etc.

E. N. Harvey, Jr.

Text. Research J. Jan. 1948

Filters in Photography

Filters in photography. Daniel Smith. *Interchem. Rev.* **6**, 3–15 (Spring, 1947).

A review of the fundamentals governing various applications of filters in photography.

E. N. Harvey, Jr.

Text. Research J. Jan. 1948

End-Group Determination in Polymers

Detection of end groups in polymer molecules. B. Dudley Sully. *Nature* **159**, 882 (June 1947).

A method for demonstrating the presence of an end group in styrene polymerized with sodium sulfite irrespective of the molecular weight and without any special purification of the polymer is reported. The method involves titration of the potassium salt of the polymer with a standardized solution of hydro-

ABSTRACTS

ANALYSIS: TESTING: LABORATORY METHODS

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Identification of Casein

Identification of casein in blends with other fibers. R. Wittwer. *Ciba Rev.* **57**, 2079 (June 1947).

Materials thought to contain casein fiber are immersed for 5 to 10 min. in a cold solution of 0.5% Alizarin SW and 1.0% of 40% acetic acid, followed by rinsing in distilled water. The aluminum compounds used in hardening the casein fibers made on the European continent act as a mordant and an intensive red Alizarin-aluminum oxide lake is found. The contrast is easily seen between the tints shown by other fibers and the intense red of the lake. J. A. Woodruff

Text. Research J. Jan. 1948

Measurement of Dye Affinity

A new method for measuring the affinity of the naphthazoles. Jacques Laneres. *Teintex* **5**, 149 (1947) (through *Chem. Abstr.* **41**, 6724*h* (Oct. 20, 1947)).

A brief discussion of dyeing, chemical, and colorimetric methods is followed by a detailed description of a new method which uses a monochromatic source of light, 2 mirrors, 2 photochemical cells, and a galvanometer.

Text. Research J. Jan. 1948

Identification of Dyes on Nylon

Detection of dyes, in particular, cellulose acetate dyes, on nylon. J. Lanczer. *Textil-Rundschau* **2**, 252–4 (July 1947).

A scheme is suggested for detecting dyes on nylon fibers. The first two types considered, basic and cellulose acetate dyes, are both soluble in dilute organic acid and give the same reactions. Therefore a test for their differentiation has been developed which is an alteration of the benzene test. It is carried out in as high a concentration as possible. The dye is boiled off from 1–2 sq. cm. of sample with about 2 cc. dilute formic acid and divided in 2 test tubes. In both tubes the standard benzene test is carried out first, adding 10% NaOH, usually 1–2 cc., until the colorless or colored carbinol base has formed; then 1 cc. of benzene is added. The whole is shaken vigorously. When the benzene layer has separated on the surface, concentrated formic acid is added until the benzene becomes the color of the original sample. Then 5 cc. of a 50% aqueous tannin solution are added to one of the test tubes and 5 cc. of water to the other. The solutions are compared. The presence of basic dyes is indicated by slow decolorization of the benzene layer, in many cases even by a distinct precipitation at the lower edge of the benzene layer. Both solutions remain unchanged in the case of cellulose acetate dyes. A table illustrates the scheme for all 9 classes of dyes. Ilse Zeise

Text. Research J. Jan. 1948

ABSTRACT REPRINTS

The JOURNAL *is again offering to its subscribers reprints of the Abstracts and Book Review sections, printed on one side of the sheet so that the items may be clipped, pasted on cards, and filed for permanent reference. Subscription to this service for 1948 is $3.00. Orders for this special service for 1948 should be mailed at once to Textile Research Institute, Inc., 10 East 40th Street, New York 16, N. Y.*

Fibroin

Studies on silk proteins. I. The properties and constitution of fibroin. The conversion of fibroin into a water-soluble form and its bearing on the phenomenon of denaturation. D. Coleman and F. O. Howitt. *Proc. Roy Soc.* **A190**, 145–69 (July 8, 1947).

Analysis of silk fibroin for various constituents is discussed, some new methods are presented, and data on composition are summarized and interpreted. A new method of determining residue weight, based on the complex formed with cuprietheylenediamine, is compared with two older methods, and the results are used to calculate the average residue weight of the (as yet) unidentified residues in fibroin. A water-soluble form of fibroin can be prepared by dissolving in cuprietheylenediamine, neutralizing, and dialyzing; on precipitation or on forming a film and stretching, the fibroin reverts to the water-insoluble form (unstretched films are water-soluble). It is considered that the native fibroin is the denatured form and that the water-soluble form has been renatured by permitting the long-chain molecules to coil up. W. E. Davis

Text. Research J. Jan. 1948

Karl Fischer Reagent

Determination of water by titration (modified Karl Fischer method). Axel Johansson. *Svensk Papperstidn.* **50**, 124–6 (1947) (through *Chem. Abstr.* **41**, 7116*b* (Nov. 10, 1947)).

The greatest disadvantage of the Karl Fischer reagent is that it is hygroscopic. This and the complicated apparatus can be eliminated by titrating in the following manner. The sample is dissolved or mixed in a solution of SO_2 and pyridine in MeOH and to this mixture is added a MeOH solution of iodine; the reagent is thus divided

chloric-acid gas in benzene while determining the viscosity continuously. R. W. Eyler
Text. Research J. Jan. 1948

CHEMICAL AND PHYSICAL RESEARCH

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Hydrolysis of Cellulose

Enzymatic hydrolysis of cellulose by *Coniophora cerebella*. F. F. Nord and J. C. Vitucci. *Nature* **160**, 261 (Aug. 1947).

In a study of the phase sequence of the degradation of the cellulosic fraction of wood, the action of *Coniophora cerebella* on filter paper and surgical cotton was investigated. It was concluded that enzymatic degradation of cellulose apparently effects a split of 1,4-glycosidic bonds rather than, or concomitant with, a split of semiacetal linkages.
Text. Research J. Jan. 1948 R. W. Eyler

Cellulose Structure

Cellulose intercrystalline structure study by hydrolytic methods. R. F. Nickerson and J. A. Habrle. *Ind. Eng. Chem.* **39**, 1507–12 (Nov. 1947).

In the hydrolysis of cellulosic fibers with aqueous hydrochloric and sulfuric acids at boiling temperature, the disordered intercrystalline chain network appears to be attacked first. This inference is drawn from sharp reductions in cuprammonium viscosity and moisture regain coincident with the rapid accumulation of glucose. Simultaneously the fibers are reduced to powdery hydrocellulose. With further hydrolysis, glucose continues to form and moisture regain slowly increases, but viscosity remains practically constant. Attack in this stage may be chiefly on lateral crystallite surfaces. Lengths of crystallites calculated from viscosity data range from 280 glucose units for cotton to 110 for high-tenacity viscose rayon. Sulfuric acid is much less active than hydrochloric in hydrolyzing cellulose and, after neutralization, does not interfere with the direct volumetric determination of glucose.
Text. Research J. Jan. 1948 Authors

Cellulose Acetate from Wood

Cellulose acetate from wood cellulose. Carl J. Malm. *Svensk Papperstidn.* **50**, 135–7 (1947) (in English) (through *Chem. Abstr.* **41**, 7110*e* (Nov. 10, 1947)).

Cellulose acetate prepared from wood pulp (typical analysis of pulp given) has 2–3 times as much color as the product from cotton linters, shows turbidity in solution, and has a lower tensile strength than the acetate from cotton linters. Possible methods for improving the quality of cellulose acetate from wood pulp are discussed.
Text. Research J. Jan. 1948

Densities of Cellulose Esters

Densities of cellulose esters. Carl J. Malm, Leo B. Genung, and John V. Fleckenstein. *Ind. Eng. Chem.* **39**, 1499–506 (Nov. 1947).

Densities of cellulose, cellulose acetates, acetate propionates, and acetate butyrates have been measured by the Archimedes and flotation methods. They have also been calculated from unit molecular weights and unit molecular volumes based on the densities of regenerated cellulose and the various acids. Observed and calculated results agree within 2 units in the second decimal place. Regenerated cellulose samples were found to have a density of about 1.52. The densities of other cellulose samples varied, depending upon their origin and degree of purity. Observed cellulose ester densities varied with composition reaching values as low as about 1.28 for the triacetate and 1.16 for the tributyrate. The Archimedes method is preferred for film samples, but the flotation method is useful for powders and fibrous samples. In the measurement of densities it is necessary to select immersion media which do not dissolve or swell the sample. Water or aqueous cadmium sulfate solutions were used for esters of high propionyl or butyryl content, and carbon tetrachloride or mixtures of carbon tetrachloride and benzene or tetrabromoethane and xylene were used for cellulose acetates and mixed esters of low propionyl or butyryl content. Calculated approximate values are also presented for simple fatty acid esters from formate to stearate. Authors
Text. Research J. Jan. 1948

Color and Constitution

Color and constitution. The absorption of light by chemical compounds. E. J. Bowen. *J. Soc. Dyers and Colourists* **63**, 281–7 (Sept. 1947).

It is said that the mathematical physicist and the chemist have produced sufficient information concerning color and its constitution to allow the formation of a numerical basis of explanation. Illustrations and brief explanations are given of the numerical application to the hydrogen atom and the hydrogen molecule. The terms "allowability" and "forbidden" are explained. Band width, shape, intensity, and the position of the band in the spectrum are explained for several chemicals by reference to information obtained from observations in hydrogen. Three aspects of the effect of solvent on light absorption of a substance are considered. First, the solvent may exert polar effects on the solute molecules, distorting their molecular symmetry and, by altering the "allowability" of a transition, alter the intensity of the band. Second, compound formation may occur, perhaps by van der Waals' forces. This will alter both the intensity and the position of the band. Third is the effect due to the variable molecular environment of solute molecules in a liquid. This alters the energy levels of all the molecules in varying degrees and leads to the broadening of absorption bands and to the smoothing out of the "partial band" structure associated with the spec-

trum of gaseous molecules. Temperature changes over a small range are said to affect light absorption only by secondary influences. An illustration is given of the change in absorption bands with changes in concentration of dye. The highly directional properties of light absorption are discussed, with examples. J. A. Woodruff

Text. Research J. Jan. 1948

Felting

Felting of animal fibers. J. Menkart and J. B. Speakman. *Nature* **159**, 640 (May 1947).

A study of the effect of sodium metabisulfite and mercuric acetate treatment upon the degree of felting of wool fibers. It is shown that maximum felting was obtained by sodium metabisulfite treatment when $\frac{1}{2}$ the length of the fibers, starting from the tip, is treated. With mercuric acetate, maximum felting is obtained when about $\frac{1}{4}$ of the length of the fibers, starting from the root end, is treated. R. W. Eyler

Text. Research J. Jan. 1948

Structure of Keratin

Structure of fibrous keratin. J. L. Farrant, A. L. G. Rees, and E. H. Mercer. *Nature* **159**, 535–6 (Apr. 1947).

On the basis of electron-microscopical evidence, it is suggested that the keratin molecule is a well-ordered discrete unit somewhat similar to that postulated for the globular proteins, and that fibrous keratin does not consist of long extended, or even partly folded, chains, but of strings of globular molecules. Electron micrographs are reproduced.

Text. Research J. Jan. 1948 R. W. Eyler

Chain Length of Polymers

Statistical theory of highly polymerized chain molecules. Shoten Oka. *Proc. Phys. Math. Soc. Japan* **24**, 657–72 (1942) (through *Chem. Abstr.* **41**, 6110*b* (Oct. 10, 1947)).

Chain length of highly polymerized molecules was calculated. The assumption that the rotation about each binding is free is discussed, and some restriction of this assumption was introduced in the calculation.

Text. Research J. Jan. 1948

Melting Point of Polymers

Thermodynamics of crystallization in high polymers. II. Simplified derivation of melting-point relationships. Paul J. Flory. *J. Chem. Phys.* **15**, 684 (Sept. 1947).

A mathematical treatment of the relationship between melting temperature and polymer constitution.

Text. Research J. Jan. 1948 R. W. Eyler

Thermodynamics of crystallization in high polymers. III. Dependence of melting points of polyesters on molecular weight and composition. Robert D. Evans, Harold R. Mighton, and Paul J. Flory. *J. Chem. Phys.* **15**, 685 (Sept. 1947).

Experimental data are presented from which it is concluded that the melting points of polymers depend in a systematic fashion on polymer constitution and that quantitative relationships can be traced.

Text. Research J. Jan. 1948 R. W. Eyler

Visco-Elastic Studies

Paper as a visco-elastic body. I. General survey. Börje Steenberg. *Svensk Papperstidn.* **50**, 127–40 (1947) (in English) (through *Chem. Abstr.* **41**, 6404*g* (Oct. 10, 1947)).

The theory of the behavior of viscose-elastic bodies is discussed, and it is shown that paper has properties characteristic of this type of body. The studies, of which this is only the first part, deal with theoretical considerations relative to the visco-elastic properties of paper. Experimental work to verify the theories was carried out with a specially designed chain balance (the construction of which is to be described in a later paper) permitting constant rate of loading as well as stretch and with which the amount of stretch can be measured to 0.5μ. The length of the test strips can be varied from 2 to 500 mm. The instrument is of the automatically recording type, regulated by means of a photoelectric device. The results are plotted as stress-strain curves with constant loading and unloading. They illustrate the effect of "mechanical conditioning" of paper and the difference between primary and secondary creep and relaxation. The results also demonstrate a marked difference in these effects where paper strips are cut at different angles to the (Fourdrinier) machine direction. Evidence that "mechanical conditioning" is affected by the paper machine is thus shown. Measurements in the cross-machine direction show difference from the center to the edge of the sheet, indicating more "mechanical conditioning" (from stretch) near the edge than in the center of the sheet. Important information on the properties of paper is likely to result from this type of study. Numerous figures, graphs, and tables illustrate the concepts and experimental data. 14 references.

Text. Research J. Jan. 1948

Paper as a viscoelastic body. II. Importance of stress relaxation in paper. Börje Steenberg. *Svensk Papperstidn.* **50**, 346–50 (1947) (in English); cf. *C.A.* **41**, 6404*g* (through *Chem. Abstr.* **41**, 7115*h* (Nov. 10, 1947)).

The significance of the relaxation of viscoelastic bodies is illustrated by comparing the strength properties of creped and noncreped papers. It may be assumed that the softness of a paper has a certain relationship to the conditions of relaxation. Steenberg shows, by means of simple mechanical models, that 2 kinds of stiffness exist: the stiffness of an elastic spring and that of a plastic material with pronounced flow properties (dashpot). In determining the stiffness of paper, usually only the elastic stiffness is considered; however, the viscosity of the viscous element is also of importance. Reversible elongation is exhibited to a considerable extent by creped paper, as well as by ordinary paper if it has not been subjected to unnecessary stretch in the paper

machine. Steenberg introduces the term *microcreping* to denote a superficially invisible creping effect causing secondary creep, which is best left in the paper by maintaining a minimum stretch in the machine, including calender and reel. The irreversible elongation (degree of microcreping) is always largest in the cross direction of the paper web and near the edge. The practice in paper mills shows that many ways of preserving or increasing the microcreping of paper are known and utilized. Paper with pronounced microcreping has better strength properties than other papers of corresponding breaking length.

Text. Research J. Jan. 1948

Chemistry of Wool

Cross bond and polymerization reactions in keratin. J. B. Speakman. *Textil-Rundschau* **2**, 243–51; 283–90 (July, Aug., 1947).

An address reviewing the work done on keratin bonds, comprising the behavior of salt-links in dyeing, cystine, and cross-link reactions—i.e., supercontraction and permanent fixation, fixation at low temperatures, elimination of the damage done to fibers by reducing agents by the formation of cross-links containing metals, use of cross-linking agents to make wool unshrinkable and to increase the felting property of animal fibers; polymerization reactions, such as depositing polymers on the surface and inside of fibers to attain changes in finishing treatments. 52 references, 12 tables.

Text. Research J. Jan. 1948 Ilse Zeise

Unshrinkable Wool

The production of unshrinkability by cross-linkage formation in wool. Part II. The rate of reaction of mercuric acetate with animal fibres. J. Menkart and J. B. Speakman. *J. Soc. Dyers and Colourists* **63**, 322–4 (Oct. 1947).

When Lincoln wool and human hair fibers are treated with a solution of mercuric acetate (0.1*M*) in acetic acid (0.1*N*), the increase in the resistance of the fibers to deformation is a linear function of the square root of the time of treatment, except in the initial stages. Determination of the slopes of the lines has shown that the rate of diffusion of mercuric acetate into Lincoln wool is 2.2 times as fast as into human hair, in general agreement with earlier observations on the rate of diffusion of Acid Orange 2G into 65s down wool and human hair at 60°C and pH 2.04. Since, in addition, Lincoln wool fibers are finer than those of human hair—i.e., since the ratio of surface to mass is greater—the elastic properties of Lincoln wool fibers are modified far more rapidly than those of human hair by treatment with mercuric acetate. In agreement with these observations, the rate at which Lincoln wool fibers are penetrated by mercuric acetate, as determined by staining the treated fibers in a solution of hydrogen sulfide and preparing cross sections, has been shown to be far greater than in the case of human hair. These results serve to explain why, in a previous study, the elastic properties of human hair fibers were found to be only slightly altered under conditions which made an all-wool flannel unshrinkable. Since it has also been shown that there is a smooth relationship between the milling shrinkage of treated patterns and the extent to which the fibers are penetrated by mercuric acetate, as observed in stained cross sections, there can be no doubt that mercuric acetate makes wool unshrinkable by modifying the elastic properties of the fibers. Authors

Text. Research J. Jan. 1948

BLEACHING: DYEING: FINISHING

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Bleaching Linen

Chemistry and the bleaching of linen. A. J. Turner. *Fibres, Fabrics and Cordage* **14**, 248–50, 252, 272 (1947); cf. *C.A.* **40**, 7642[8] (through *Chem. Abstr.* **41**, 6727*a* (Oct. 20, 1947)).

A discussion of ancient bleaching practice, bleaching powder, bleaching in the 19th century, modern bleaching, and newer chemical bleaching agents.

Text. Research J. Jan. 1948

Automatic Slasher Controls

Modern slasher room features automatic controls. P. M. Thomas. *Textile World* **97**, 135, 137, 157 (Sept. 1947).

A description of the automatic controls for the slashers and size vats installed in the Seminole Mills. The slashers are 2-cylinder cotton slashers now processing blends of synthetic fibers. The improvement of the control system has increased production from 14 to 25 yds. per min. to 25 to 55 yds. per min. on the same warp construction. A Brown Moist-O-Graph, in conjunction with a variable-speed drive, controls slasher production on the basis of the moisture content of the warp. The variable speed drive is equipped with a generator that starts the slasher on A.C. current and switches to D.C. current when the slasher is running at high speed. Warp stretch is controlled by 2 sets of feed-roll drive pulleys. One set of pulleys drives the feed-rolls that feed the yarn into the size-box. The other set drives the feed rolls that deliver the yarn from the size box to the cylinder. Yardage tachometers at the size-box feed roll and at the cylinder delivery roll provide an accurate check of the actual stretch of the yarn. The section beams in the creel are equipped with air-actuated brakes to adjust the warp let-off with the speed of the slasher. Temperature controls regulate the pressure of the steam in the cylinders and the temperature of the size in the size-box. The level of the size in the size-box is controlled automatically by means of electrodes connected to valves in the lines from the size-storage kettles. The temperatures of the size-cooking kettles and size-storage kettles are also automatically controlled. L. A. Landau

Text. Research J. Jan. 1948

Slashing Problems

Slashing problems discussed. Anon. *Am. Wool and Cotton Reptr.* **61**, 7–8 (Oct. 23, 1947).

Questions and answers pertaining to the operation of slashers as discussed at a recent meeting of the Textile Operating Executives of Georgia. The performance of starch stabilizers, variable speed drives, and synthetic squeeze-roll coverings, percentage of stretch recommended, control of waste, and slasher maintenance were discussed. Actual mill practices and experiences were cited. A. L. Landau

Text. Research J. Jan. 1948

Theory of Dyeing

An absorption isotherm for direct dyes. J. Crank. *J. Soc. Dyers and Colourists* **63**, 293–6 (Sept. 1947).

A theory for dyeing cellulose with direct dyes is given, and, commencing with the Langmuir isotherm for the absorption of molecules in a unimolecular layer by a surface containing a finite number of active sites, a simple formula is derived. The equilibrium absorption of dye is related to the dye-bath concentration, the concentration of foreign electrolyte in the dye-bath, and the temperature. Theoretical results are compared with equilibrium dyeings of cellulose by Chrysophenime G in the presence of sodium chloride. The calculation of the energy of dyeing cellulose with this dye is compared with the value obtained by others for the mean energy of the bonds between cellulose and dye. J. A. Woodruff

Text. Research J. Jan. 1948

Dyeing Damaged Wool

The dyeing of wool damaged by exposure to light. H. Rosti. *Ciba Rev.* **58**, 2221–2 (1947) (through *Chem. Abstr.* **41**, 7121*e* (Nov. 10, 1947)).

Exposure to light causes increased swelling, marked shrinkage, a harsh handle, and diminished tensile strength owing to decomposition of the cystine group, reduction of S to H_2S, and atmospheric oxidation of H_2S to H_2SO_4. If acid dyes are used the goods should be boiled with Hydrosulfite BZ water solution before dyeing, or should be bleached with H_2O_2; acid dyes should be used, because a neutral dye bath would degrade the damaged wool still further. If AcOH has too strong a reserving action on damaged wool, H_2SO_4 may be used to deepen the shade. If H_2SO_4 causes too great a contrast in shade between damaged and undamaged parts HCOOH may give better results. Generally, wool damaged by light is dyed very strongly, strongly, and weakly with H_2SO_4, HCOOH, and AcOH, respectively, in the dye bath. HCOOH is well suited for dyeing faded woolen goods. Suitable dyes are listed.

Text. Research J. Jan. 1948

Printing on Vinyl Film

Printing on vinyl film. Chester M. Robbins. *Interchem. Rev.* **6**, 16–21 (Spring, 1947).

Gravure printing processes for textiles have been largely adopted for decorating films comprising copolymers of either vinyl chloride or vinylidene chloride with vinyl acetate. The procedures followed and general characteristics of the ink formulations used are described. Such applications are unique in that the inks become fused into the vinyl sheeting. New developments of considerable potential importance are the use of continuous printing methods in "topping," the all-over coloring of heavy-gage embossed film, and in "processing" or "souping" thick films with special engravings and inks to provide a desired degree of gloss. Silk-screen, air-brush, and transfer-printing techniques are also used to produce shower curtains, table covers, luggage, upholstery, etc., from vinyl films. [Cf. *T.R.J.* **17**, 402.]

E. N. Harvey, Jr.

Text. Research J. Jan. 1948

Finishing Ranges

Efficiency and flexibility offered by finishing ranges. C. N. Rabold. *Textile World* **97**, 106–11 (Oct. 1947).

A description, illustrated with sketches, showing the various types of finishing ranges. There are two general types: continuous scouring and bleaching ranges using caustic soda and hydrogen peroxide, and continuous dyeing ranges. The use of these ranges reduces the length of time consumed in bleaching to a few hours, and dyeing may be completed in a matter of minutes rather than hours. Another advantage of these ranges, besides reduction in time and labor, is the production of a more uniform product. Operational speeds of the preparatory ranges vary from a maximum of approximately 150 yds. per min. for the open-width ranges, to 175 yds. per min. for the slack washer-rope systems, and 300 yds. per min. for the tight-strand rope systems. Practically any class of dyes may be applied to almost any fabric as efficiently as was possible on the older-type systems. Most of the ranges are constructed of noncorrosive metals. Modern controls record, measure, and proportion factors such as the temperature, chemical feed, steam, water, levels, and time. Cloth-preparation ranges are divided into two general classifications, depending upon whether the cloth is handled in the form of a rope or in open-width. Du Pont and Becco J-boxes are described and illustrated. A. L. Landau

Text. Research J. Jan. 1948

Detergents

The chemistry and application of detergents. J. A. Hill. *J. Soc. Dyers and Colourists* **63**, 319–22 (Oct. 1947).

The nature of detergents and their divisions into anion-active, cation-active, and nonionic chemical classes is discussed. Equations for the evaluation of wetting power and penetration are given. The applications of the various detergent types are reviewed. Emphasis is placed on the possibilities of the nonionic materials. J. A. Woodruff

Text. Research J. Jan. 1948

Milling and Carbonizing Faults

Milling and carbonizing faults. Anon. *Can. Text. J.* **64**, 40, 42 (May 30, 1947).

The elimination of mill-rigs, listing, stains, uneven dyeing, and other faults are discussed.

J. A. Woodruff

Text. Research J. Jan. 1948

Polyvinyl Butyral Coating

Characteristics and application of polyvinyl butyral coatings. D. S. Plumb. *Textile Age* **10**, 64, 66, 68, 69 (Oct. 1947).

The commercial use of polyvinyl butyral as a transparent textile coating was first attempted in 1946. A vinyl butyral coating is not fundamentally different from, and is applied in the same manner as, rubber, nitrocellulose, or other vinyl resins. It is unique in that it forms a completely transparent coating with a dull finish so that for all practical purposes it is invisible. The coating is very thin, $1\frac{1}{2}$ oz. per sq. yd. for most fabrics, or a film only 0.0015 in. thick. The coating renders the fabric waterproof and stain-resistant. Vinyl butyral coatings have a high resistance to abrasion and to discoloration due to exposure to weather. The compound, with alcohol or naphtha as a solvent, is applied in 3 coats by a knife coater and then vulcanized by hot air. The fabrics coated must be woven with a flat, close weave for best results. The dyes used must be tested in each instance since difficulties in dye-fastness have occurred with this type of waterproofing compound.

A. L. Landau

Text. Research J. Jan. 1948

FIBERS: YARNS: FABRICS: MECHANICAL PROCESSES

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Fiber Structure

Some principles of the structure of synthetic fibers. H. F. Mark. *Am. Dyestuff Reptr.* **36**, P323–7 (June 16, 1947).

A concise review of the relation between the molecular structure of high polymers and their mechanical behavior. The effect of average degree of polymerization, molecular-weight distribution, the internal flexibility of the individual molecules, and the mutual arrangements of the chain molecules in a polymer are discussed. Intrinsic flexibility of the individual chains affects mainly the rate of recovery from the extended state and its temperature dependence; the mutual arrangement of molecules determines the relative degree of internal and external or macromolecular Brownian movement, which in turn determines the extent to which the solid, liquid, or rubbery state will predominate in the sample. Synthesizing a polymer for practical purposes, e.g., a fiber, is likened to the task of a metallurgist devising an alloy of optimum properties; a chain molecule with a D.P. around 1,000, with a certain degree of internal flexibility and an appropriate mixture of solid, liquid, and rubbery properties is required.

K. S. Campbell

Text. Research J. Jan. 1948

Elastic Properties of Nylon

The elastic properties of nylon 66. Vincenzo Navarra. *Materie plastiche* **13**, 9–12 (1947) (through *Chem. Abstr.* **41**, 5726*g* (Sept. 10, 1947)).

The elasticities of nylon 66 (from hexamethylenediamine and adipic acid), nylon 6 (from ϵ-aminocaprolactam), and natural silk are compared. Both nylon 66 and 6 undergo higher elongations (up to 19%) than silk (not quite 10%). Their instantaneous recovery is around 99% of total recovery compared to about 94% for silk; this drops to 97.7% (93.3%) after 60 tests. A certain amount (5.32%) of non-elastic (plastic) deformation also occurs. The raw fiber of nylon 66 can be stretched as much as 600%, whereas the fiber which has been drawn to 400% has a maximum elongation of 30%. The explanation is offered that the fiber when subjected to slow and gradual stretching has time to dissipate the energy first by parallel orientation and then by the mechanism of relaxation, *i.e.*, by molecular flow at the expense of hydrogen bonds, whereas in intense and rapid drawing there is no time for compensation by structural adaptation and rupture would occur if the drawing were not limited to 400%.

Text. Research J. Jan. 1948

Resistance to Weathering

Resistance of textile fibers to sun exposure and weathering. J. Salquain. *Teintex* **5**, 155 (1947) (through *Chem. Abstr.* **41**, 6725*f* (Oct. 20, 1947)).

Discussion of increased temperature, activation, and dissociation of fiber molecules due to sun exposure.

Text. Research J. Jan. 1948

Quality Control

Suggestions for quality control in spinning finer cotton yarns. W. J. Stone. *Textile Age* **10**, 52, 54, 56, 58 (Oct. 1947).

The evenness which is essential to spinning fine yarn must be maintained by testing each preparatory process. The author states that the productive capacity of each machine is limited by the effect on the evenness of the fibers being acted upon. Excessive production decreases the evenness of the lap, sliver, roving, or yarn. To attain the maximum production comparable with the quality of yarn desired, each stage of the manufacturing layout must be checked with suitable instruments. The picker lap may be checked with a lap meter for evenness; it should be held within $\frac{3}{4}$ of an oz. variation. Poor laps are caused by weak air current, inefficient or dirty evener motions, or a lack of coordination of the various machines in the opening line. The sliver produced by the card may be tested by the sliver tester, which charts the variations in the thickness of the sliver. This instrument can be used to check the drawing sliver or comber sliver also. Differ-

ent settings and different speeds of drafting rolls may be tested and checked by the sliver tester to find the most efficient organization for the local conditions. The spun yarn is best tested by finding the breaking strength and by visual examination of samples wound on a blackboard. A. L. Landau

Text. Research J. Jan. 1948

Carpet Yarns

Carpet yarns. S. Kershaw. *J. Text. Inst.* **38**, 431–3 (Sept. 1947).

An analysis of carpet-yarn manufacture classified with reference to types of wools, wool sorting, spinning, twisting and cabling, reeling, scouring and dyeing, and rewinding. Further subdivision is made with the inclusion of a broad review of each subject. Many practical processing suggestions are given.

Text. Research J. Jan. 1948 L. A. Fiori

Crossbred Wools

New-type worsted yarns and fabrics from crossbred wools. W. Hardacre. *Text. Mercury and Argus* **117**, 521, 523, 525 (Oct. 17, 1947).

Particular mention is made of the requirements for worsted-type lightweight fabrics and tropical suitings. The author stresses the unsuitability of using yarns made from 100% crossbred wools for these types of fabrics and discusses the suitability of blending crossbred wools with rayon staple of desirable lengths and denier to produce the fine yarns possessing the physical properties required for these materials. The possibility of raising the count limit by a rayon-crossbred wool blend is demonstrated by data, which show that the count percent increase of blended yarns over yarns spun from 100% crossbred wool was from 13% to 75%. It was also indicated by yarn tests that blended yarns were, in every case, stronger. It is concluded that by the proper combination of rayon-wool percentages there is opportunity of increasing the outlet of crossbred wools by making new types of lightweight fabrics, especially dress goods. L. A. Fiori

Text. Research J. Jan. 1948

Coated Fabrics

Oilcloth pioneers in Maine. Charles R. Bragdon. *Interchem. Rev.* **5**, 102–9 (Winter, 1946–47).

Historical sketch of the Wadsworth & Woodman organization, manufacturers since 1904 of coated fabrics at Winthrop, Me.

E. N. Harvey, Jr.

Text. Research J. Jan. 1948

Corkscrew Weaves

The construction of corkscrew weaves. Alex. J. Bennet. *Text. J. Australia* **22**, 496–7 (Sept. 20, 1947).

Construction details of typical and unusually interesting and useful corkscrew weaves are described. Design plans illustrating these weaves are shown. Although corkscrew weaves are used largely in plain cloths, they lend themselves admirably to color effects. One of the chief advantages gained through their use is the opportunity of inserting a cheaper quality of material for the interior threads than is used on the surface of the fabric.

Text. Research J. Jan. 1948 L. A. Fiori

Carding Staple Rayon

Production rates in the carding of short-staple "Fibro" on the revolving flat card. W. E. Morton and I. A. H. Shahin. *J. Text. Inst.* **38**, P310–18 (Aug. 1947).

Experiments were performed to determine to what extent production of short-staple rayon could be increased on the card without introducing excessive neps and cloudiness, and to report on the possibilities of lengthening the stripping interval. To increase productivity of the card and not introduce too many variables, the raw material (Fibro, $1\frac{7}{16}$-in., 1.5 den., bright), weight of the lap (15oz. per yd.), flat speed ($1\frac{1}{8}$ in. per min.), and card settings (similar to those used for long-staple Egyptian cottons) were maintained constant throughout. To provide the flexibility required by the experiment, the two variables, doffer speed and rate of feed, were controlled independently of the cylinder by an electric motor. As a result, it was possible to investigate each variable separately and then in combination. The card was found to be capable of an output of approximately 120 lb. of sliver without stripping or deterioration in quality, judged by appearance. Hence the investigators suggest that at the doffer speed in current use, the interval between strippings might be increased to about a full working day without sacrificing quality. A maximum rate of production of 31 lb. per hr. with a doffer speed of 25 r.p.m. was attained without causing undue nepiness or cloudiness. However, certain precautions, such as calender draft changes, were necessary to avoid sources of error. The possibility that other cause of quality deterioration in the web but not apparent to the eye was eliminated by severe spinning tests. It was concluded that sliver produced by carding at high doffer speed after 230 min. of continuous running gave a yarn no weaker and no more irregular in count than that spun from sliver made at slower doffer speeds. Whatever the carding conditions, some fiber breakage occurred as the material passed through the card, but its effect on the mean length of fibers was substantially the same for all tests. The experiments showed that the working surfaces of the revolving flat card are capable of being much more heavily loaded than is customary. The authors emphasize the fact that neither the limit of production nor the limit of running period was reached in this investigation.

Text. Research J. Jan. 1948 L. A. Fiori

Woolen Carding

Some recent trends in woolen carding. R. W. Wright and A. Brearley. *J. Text. Inst.* **38**, P319–39 (Aug. 1947).

This report covers present general trends in woolen carding, especially the relative merits of converting the English or Yorkshire carding principles to the continental system of woolen carding. Consideration is given to preparation of raw ma-

terials, establishment of mechanical details, and attainment of uniform and ideal running conditions. In continental blending, the arrangements provide for cleaning, spray oiling, and conveying, for which most English mills lack facilities. Few woolen mills use artificial humidification, yet the data show that the card is an ideal machine for conditioning wool. There is conclusive evidence that the regain of wool in the later stages of carding is controlled by the atmosphere of the room rather than by the regain in the hopper. For wool of low (6.2%) and high (21.0%) regains in the hopper of a semicontinental card running in atmospheric conditions of 68°F, 47% R. H. regain of the slubbing was practically the same, 11.4% and 13.8%, respecspectively. The automatic hopper weighings are a cause of variation in thickness along a woolen thread. Recent tests show that overfeeding and irregularity of weighing can be reduced considerably by aiming at as thin and slow a feed as possible. The beater comb must be set as close to the spiked lattice as is practical and the lattice run at as slow a speed as possible. Long fibers and matted blends tend to increase variations. Electrically controlled hoppers, as advocated in the U. S. A. but not yet adopted in England, increase sensitivity. Use of metal cylinders is recommended, whatever the type of material in process. With the present mechanical design, cylinder (54-in. diameter) speeds in excess of 130 r.p.m. are not possible since the strongest available continental fillet clothing may begin to leave the cylinder surface at around 140 r.p.m. The tendency today, whether or not the continental principles are followed, is to install metallic-covered foreparts, the remainder of the machine being fillet-clothed throughout except the fancies, which are covered with sheets. For great production and high card speeds, fillet clothing, having a cotton-rubber-felt foundation, is recommended. With high speeds and this type of clothing, settings should be too open rather than too close. Strippers are set to touch, but not enter the workers, as in many Yorkshire mills. Fancies are likewise set lighter, with their lifting power increased by higher speeds. The value of high cylinder speeds was indicated by a marked reduction of both the number and size of hard threads in a blend. Also, the same improvement was noted in cleaning neps. Increased opening power at higher speeds was not accompanied by increased fiber breakage as noted by yarn strength tests obtained, which showed a slight improvement in count strength products for the high cylinder speed. There is little evidence that greatly superior results are obtained by reversing the direction of some of the workers. At all rates of feed the clearing efficiency of the doffer increased with increasing doffer speeds—with more pronounced effects at greater rates of feed. The tape condenser appears to be rapidly superseding the ring doffer. For a machine which is to deal with blends containing vegetable matter, hard threads, and skin, the Peralta rollers are considered indispensable. Their worth is substantiated by 4 tables giving analyses of various blends, comparative yarn strengths, shoddy blend yarn tests, and number of ends down in spinning. The possibilities of modifying plants to work on semi-continental principles are advanced. Data on machinery and production for converted cards are reported. L. A. Fiori

Text. Research J. Jan. 1948

Warping

Progressive steps—warp to loom. W. Middlebrook. *Text. Mfr.* **73**, 397–8 (Sept. 1947).

In this discussion the author stresses the practical side of warping. Steps in the process are outlined, with many practical suggestions to increase efficiency. L. A. Fiori

Text. Research J. Jan. 1948

Effect Threads

Weaving suitings with rayon and silk effect threads. Anon. *Silk and Rayon* **21**, 1260 (Sept. 1947).

A practial weaver gives some operational suggestions on how to get good results in the weaving of suitings from rayon and silk effect threads. The amount of friction on the extra rollers containing these effect threads and the relative speeds of roller and warp beam are important. These two conditions can be determined by simple tests described in this report. Two illustrative designs are shown.

Text. Research J. Jan. 1948 L. A. Fiori

Preparatory Machinery

Modern methods of preparation for weaving cotton and rayon staple. L. Armstrong. *Text. Weekly* **40**, 748–52 (Oct. 24, 1947).

After reviewing the problems created in winding, beam warping, sizing, drawing-in, and filling preparation by the ever-increasing size of ring spinning packages, the author calls attention to the modern machines especially designed to cope with this trend. L. A. Fiori

Text. Research J. Jan. 1948

O. T. S. REPORTS*

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Fibers

First meeting of the cooperative group for textile fibers, June 28, 1940 (in German). Reichsamt für Wirtschaftsausbau. PB L 52006; 120 pp.; microfilm, $3.00 —photostat, $8.00 (through *Bib. Sci. and Ind. Reports* **7**, 61 (Oct. 3, 1947)).

This report has been divided into 14 parts which may be obtained individually at a price of $1.00 each. Of particular interest are the following: "Influence of Methods of Preparation on the Properties of Pulp and Staple Fiber" by R. E. Dorr, 11 pages; "Presenting Problems in the Production and Improvement of Staple Fiber" by J. Kleine, 12 pages; "Saving of Chemicals in the Viscose-Spinning Operation" by E.

* Copies of these reports may be obtained directly from the Office of Technical Services, Department of Commerce, Washington 25, D. C. Orders should be accompanied by check or money order payable to the Treasurer of the United States.

Bauer, 10 pages; and "Problems and Present Status of Acetate Staple-Fiber Production," by Wolfgang Gruber, 8 pages.

Text. Research J. Jan. 1948

Tow-to-Top Conversion

Staple fiber tow-to-top conversion methods in Germany. A. Laszlo *et al.* (BIOS Final Rept. 1096, Item 22, 31.) PB L 78213, Apr. 1947; 167 pp.; microfilm, $4.00—photostat, $12.00 (through *Bib. Sci. and Ind. Reports* **7**, 232 (Oct. 17, 1947)).

This report describes the staple fiber tow-to-top conversion methods in Germany. The information was obtained from inspection of all German plants in the three occupation zones in Western Germany, as well as from individual engineers to whom patents had been granted for staple fiber tow-to-top developments. Much detailed information is contained in this report. The investigation is concerned, however, more with trends of unfinished developments than with actual production plants. The investigators have found methods developed into successful Proto-Types which have not been known until now outside of Germany, and for which no German patents had been issued by the end of the war. Part 1 of the report is a review of the German top-making patents and patent applications. This section also contains abstracts of the most recent I. G. top-making patent applications. Part 2 deals with every known method used in Germany for top-making, including all available information about washing, drying, and some other processes. Part 3 consists of travel reports on the plants visited. Photographs, sketches, and diagrams illustrate the text.

Text. Research J. Jan. 1948

Continuous Rayon Spinning

Continuous spinning of cuprammonium rayon at J. P. Bemberg, Wuppertal, and I. G. Farbenindustrie, Dormagen. A. R. Knight *et al.* (BIOS Final Rept. 1380, Item 22.) PB L 79641, Nov. 1946; 77 pp.; microfilm, $2.00—photostat, $6.00 (through *Bib. Sci. and Ind. Reports* **7**, 232 (Oct. 17, 1947)).

This report gives detailed information regarding the development of the continuous spinning system and of the latest continuous spinning machine now in the course of construction at J. P. Bemberg. It also gives details of the continuous spinning machine which was seen in operation at I. G. Farbenindustrie, with an account of the mode of operation and of proposed modifications for future machines. A copy of a report by Dr. Wichert of J. P. Bemberg, information regarding relevant J. P. Bemberg patents, and drawings are appended. Several photographs and sketches also illustrate the report. Spinning of continuous-filament cuprammonium rayon on the continuous system developed by J. P. Bemberg and I. G. Farbenindustrie has been described briefly in the following reports: (1) C.I.O.S. XIX-5, item 22 (PB 177, v. 1, p. 26, this *Bibliography*); (2) C.I.O.S. XXVIII-1, item 22 (PB 377, v. 1, p. 26); (3) B.I.O.S. 196, item 31 (PB 19265, v. 1, p. 1430); (4) B.I.O.S. 454, item 22 (PB 77709, v. 6, p. 547); and (5) B.I.O.S. 574, item 22 (PB 34729, v. 3, p. 57). For a related report see also FIAT Final Report 653, PB 78266.

Text. Research J. Jan. 1948

Cuprammonium Process

Cuprammonium-process synthetic rayon in Germany. J. I. Taylor. (FIAT Final Rept. 653.) PB L 78266, Mar. 1947; 17 pp.; mimeo, $0.50 (through *Bib. Sci. and Ind. Reports* **7**, 232 (Oct. 17, 1947)).

This report reviews the processes used in the manufacture of cuprammonium rayon fibers and summarizes the significant developments in this field during the war years. The information was obtained from I. G. Dormagen and J. P. Bemberg A. G., Barmen. Six photographs illustrate the following: (1) continuous spinning machine for cuprammonium rayon; (2) second bank of spinning funnels (rear of same machine as (1)); (3) washing machine; (4) tank for oil preparation with rollers; (5) system of 3 rollers behind the dryer and part of the apparatus for moistening the rollers; and (6) the winding machine. FIAT Final Report 34 (PB 1120, v. 1, p. 70, this *Bibliography*), entitled "Preparation of cuprammonium spinning solution and special processes at I. G. Farben, Dormagen," by G. P. Hoff and others, describes details of auxiliary processes as well as the staple process. See also BIOS Final Report 1380, item 22, entitled "Continuous spinning of cuprammonium rayon at J. P. Bemberg, Wuppertal, and I. G. Farbenindustrie, Dormagen," by A. R. Knight and others (see column 1, this page).

Text. Research J. Jan. 1948

Silk and Ramie

Silk and ramie yarn production in Germany. G. A. Aldred *et al.* (BIOS Final Rept. 1328, Item 22, 31.) PB L 79430, Nov.–Dec. 1946; 31 pp.; microfilm, $1.00—photostat, $3.00 (through *Bib. Sci. and Ind. Reports* **7**, 61 (Oct. 3, 1947)).

Eight factories were visited and a detailed report is given on each visit covering the following: ramie spinners; sericulture and net silk processing; silk spinners; textile machinery makers. Ten drawings and photographs of textile machinery are included.

Text. Research J. Jan. 1948

German Wool Dyeing

A survey of the German woolen and worsted dyeing and finishing trades. G. G. Hopkinson *et al.* (BIOS Final Rept. 1327, Item 22.) PB L 80610, Jan. 1947; 53 pp.; microfilm, $2.00—photostat, $4.00 (through *Bib. Sci. and Ind. Reports* **7**, 62 (Oct. 3, 1947)).

This report covers a detailed survey of the German wool dyeing and finishing trade. The investigations of 25 German firms were confined solely to dyeing and/or finishing. Twenty-one sketches and photographs are included.

Text. Research J. Jan. 1948

German Wool Industry

Miscellany of German wool textile industry. A. P. T. Holden. (BIOS Final Rept. 1362, Item 22, 31.) PB L 80375, Aug. 1946; 51 pp.; microfilm, $2.00—photostat, $4.00 (through *Bib. Sci. and Ind. Reports* **7**, 62 (Oct. 3, 1947)).

This document contains 24 reports on textile mills investigated in Germany, describing the present activities, products manufactured, and methods and machinery used. Twenty illustrations, sketches, and layouts of machinery are included.

Text. Research J. Jan. 1948

MISCELLANEOUS

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Textile Bags

Textile bags. Anon. *Modern Packaging* **20**, 140–2 (May 1947).

Plastics are being used to add sheen to bag surfaces and to strengthen the cloth yet leave it porous, making possible lighter bags of equal or greater carrying strength than those now in use. Laminated textile bags make possible retention of a measured moisture content, important for some commodities. They are laminated with asphalt, latex, or synthetic resins. Open-mesh cotton bags have proved to be an outstanding development for packaging fruits and vegetables. R. B. Evans

Text. Research J. Jan. 1948

Short Harsh Cottons

Short harsh cottons. U. S. Tariff Commission. Washington, U. S. Government Printing Office, 1947. 72 pages. 20 cents.

Imports of cotton from India (and China and the Dutch East Indies before the war), predominantly of short-staple, harsh or rough types, totaled 79.9 million lbs. in 1946 as compared with 26.4 million lbs. in 1939. Use of short harsh cotton in cotton blankets, in battings, waddings, and felts for such purposes as filtering milk and making shoulder pads, has been long established. Recently its use in mattress and upholstery felts has been greatly increased because of shortages of linters and mill wastes. Its competitive impact on American cotton and cotton linters is discussed.

Text. Research J. Jan. 1948 R. B. Evans

Cordage Supply in U. S.

United States cordage supply policy. Isabel Ann Baldwin. *Dept. State (U. S.) Bull.* **17**, 111–15 (July 20, 1947).

During 1934–38, the United States consumed ⅓ of the world's exportable supply of hard fibers. Tariffs affecting cordage fibers are discussed. History of efforts to secure and conserve stocks of hard fibers during the war are noted but it is stated that only 3 months' supply was on hand at the end of the war. Abaca production in Central America was expanded from 400 long tons in 1942 to almost 10,000 long tons in 1945 and further expansion to 29,000 long tons in 1949 is expected. Because of continuing civilian shortages no hard fiber has been stockpiled since the end of the war although this has been authorized by Congress. R. B. Evans

Text. Research J. Jan. 1948

Gums and Mucilages

The chemistry of some plant gums and mucilages. E. L. Hirst and J. K. N. Jones. *J. Soc. Dyers and Colourists* **63**, 249–54 (Aug. 1947).

The chemistry of some plant gums, mucilages, and pectic materials is given with the object of showing the general type of structures present in these related substances and to form the following generalizations: a comparison of the structures of cellulose, alginic acid, and pectic acid shows that these polymers although derived from sugars of different configurations have very similar geometrical arrangements in their structural formulas; gums and mucilages all possess ramified structures which cannot be derived in the plant directly—i.e., without intervention of hydrolysis from preformed polysaccharides such as starch or glycogen; the gummy or thickening properties of these polysaccharides seem to be dependent upon the solubility of the gum in water and its capacity to permit the formation of rigid but disordered structural networks by hydrogen bonding or loss of water.

J. A. Woodruff

Text. Research J. Jan. 1948

Maleic and Fumaric Resins

Maleic and fumaric resins. Charles S. Rowland. *Interchem. Rev.* **5**, 83–94 (Winter, 1946–47).

The use of maleic acid and its isomer, fumaric acid, in making commercially useful resins is based on their ability to undergo both condensation and addition polymerization reactions. Polymerization via the unsaturated linkage and/or via the carboxyl group may lead to a variety of widely used thermoplastic and thermosetting resins, which the author classifies, with examples, as esters, polyesters, Diels-Alder addition products, heteropolymers, and substituted succinic acid condensation products. Various examples of these are discussed from the standpoints of reaction conditions, chemical structure, modification by copolymers, physical characteristics, and uses. Glycol maleates, for instance, are cited as polyesters, which in admixture with polymers, such as polystyrene, are suitable for low-pressure lamination with glass cloth, paper, etc., and thus find application in aircraft parts, lampshades, electrical appliances, etc. 26 references.

E. N. Harvey, Jr.

Text. Research J. Jan. 1948

Acceptance Sampling Plan

Acceptance sampling by variables, with special reference to the case in which quality is measured by average or dispersion. John H. Curtiss. *J. Research Natl. Bur. Standards* **39**, 271–90 (Sept. 1947).

A presentation of the theory and practice of certain types of acceptance sampling plans based on the

statistical tests of hypotheses. The basic concepts of the statistical theory are discussed in detail, then applied to obtain a number of specific formulas for the single sampling case. Author

Text. Research J. Jan. 1948

Ultrasonics

Ultrasonics. A. Heuberger. *Textil-Rundschau* **2**, 88–95 (Mar. 1947).

An address. A physical explanation of ultrasonic waves, with only a very general reference to their use in research. Ilse Zeise

Text. Research J. Jan. 1948

Unshrinkable Wool

Methods for the preparation of unshrinkable wool. H. Briggs. *Textil-Rundschau* **2**, 75–9 (Mar. 1947).

A review of patented modern methods.

Text. Research J. Jan. 1948

Market Research

Market research in industrial fields. John P. Duane. *Interchem. Rev.* **5**, 95–101 (Winter, 1946–47).

Methods of obtaining market research information and the use of such data are discussed with emphasis on industrial consumers as a market.

E. N. Harvey, Jr.

Text. Research J. Jan. 1948

PATENT REFERENCES

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Dyeing Acetate

Process for coloration of textile materials containing organic derivative of cellulose with leuco sulfuric esters of vat dyestuffs. Cyril M. Croft and Walter H. Hindle (to Celanese Corporation of America). U. S. 2,428,833 (Oct. 14, 1947).

Organic derivatives of cellulose are dyed alone or in combination with cotton or regenerated cellulose to a uniform shade by padding through a dye bath consisting of a leuco vat dye sulfuric acid ester and sodium nitrite dissolved in approximately 30% of water and 70% of aqueous ethyl alcohol, drying in heated air, and then oxidizing the dye, washing, scouring, and drying the dyed fabric. The fabric is dyed to a union and the color is fast to washing and gas-fume fading. J. A. Woodruff

Text. Research J. Jan. 1948

Dyeing of cellulose acetate fabrics with direct dyeing dyestuffs, lower aliphatic alcohols, and lower aliphatic acids. Cyril M. Croft and Walter H. Hindle (to Celanese Corporation of America). U. S. 2,428,834 (Oct. 14, 1947).

Cellulose acetate textile materials are dyed by mechanical impregnation with a solution of a direct-dyeing dye in an aqueous medium of at least 60% by weight of a lower aliphatic alcohol and 1% to 8% of a lower aliphatic acid and then dried rapidly. By direct-dyeing dyes is meant those which produce their ultimate shade without use of pre- or after-treatment to effect chemical change in the structure or character of the material being dyed. J. A. Woodruff

Text. Research J. Jan. 1948

Dyeing of fabrics comprising cellulose acetate with an alcohol-thiocyanate swelling mixture. Cyril M. Croft and Walter H. Hindle (to Celanese Corporation of America). U. S. 2,428,835. (Oct. 14, 1947).

Cellulose acetate textile materials are dyed by mechanical impregnation with an aqueous dye liquor containing, in addition to the dye, about 60% by weight of a lower aliphatic alcohol, 2% to 5% by weight of a lower aliphatic acid, and 1% to 3% by weight of a salt of thiocyanic acid, which is a swelling agent for the cellulose acetate material, and then washing the wet textile material immediately after padding. Changes in the properties of the chemicals in the dye bath may be made when various types of dyes are used. J. A. Woodruff

Text. Research J. Jan. 1948

Vat Dyes on Acetate

Process for dyeing textile materials comprising a cellulose carboxylic ester with vat dyes. Herbert G. Scull (to Eastman Kodak Co.). U. S. 2,424,857 (July 29, 1947).

Cellulose acetate materials are vat dyed in solid color by padding the material through a dispersion of unreduced vat dye, an alkaline reducing agent inactive at temperatures up to 140°F, and a thickening agent. The padded material is then dried at an elevated temperature without contact with surfaces which would cause smearing. The material is then steamed to reduce the vat dye and to saponify the surface of the fibers. Conventional oxidation and soaping follows. It is said that textile materials containing wool, cotton, or viscose rayon in addition to cellulose acetate are dyed uniformly. J. A. Woodruff

Text. Research J. Jan. 1948

Printing Acetate Fabrics

Printing of cellulose acetate fabrics with acid dyes. Cyril M. Croft and Walter H. Hindle (to Celanese Corporation of America). U. S. 2,428,836. (Oct. 14, 1947).

Cellulose acetate is printed with a printing paste comprising an acid dye, 30% to 60% by weight of a lower aliphatic alcohol, 2% to 4% by weight of a lower aliphatic acid, 6% to 10% by weight of an inorganic salt of thiocyanic acid, which is a swelling agent for the cellulose acetate, and 1.5% to 5% by weight of a water-soluble thickener, washing the treated material directly after printing, and then drying. The resultant print is described as fast to light, to scouring, and to gas-fume fading. J. A. Woodruff

Text. Research J. Jan. 1948

Stripping Cards

Means for stripping carding apparatus. William H. Goldsmith, Jr. (to Abington Textile Machinery Works). U. S. 2,422,011 (June 10, 1947).

An automatic pneumatic stripping apparatus which effectively strips

the cylinder with a minimum of waste and uninterrupted production, which operates in the zone occupied by the flats and in conjunction with them. Mechanical features are the suction nozzles mounted through the inverted T-shaped section of the flats to a point in the same plane as the flat wires and the suction manifold which provides suction to the nozzles. To carry out stripping according to a predetermined pattern, each flat has a single suction nozzle, with the nozzles in successive flats positioned to enable all portions of the card cylinder to be stripped. As each flat moves into working position, the suction manifold engages it, strips the cylinder through the nozzle for a limited interval, then disengages itself preparatory to being lowered into the following flat. L. A. Fiori

Text. Research J. Jan. 1948

Esterification of Cellulose

Process of esterifying cellulose fibers. Andreas Ruperti (to Society of Chemical Industry). U. S. 2,420,499 (May 13, 1947).

Esterification of regenerated cellulose with anhydrides of organic acids is accomplished with retention of structure by impregnating the cellulose with a solution of a catalyst, removing the solvent, impregnating with a liquid anhydride, removing the excess anhydride, and subjecting the still unacylated impregnated material to the action of a circulating gas at a temperature of at least 100°C. The catalysts are alkali metal salts of weak acids and, specifically, potassium acetate.

J. A. Woodruff

Text. Research J. Jan. 1948

Conditioning Cotton

Method and system of conditioning fiber. J. Blewett (to Murray Co.). U. S. 2,421,477 (June 3, 1947).

Cotton mixtures containing seed cotton, trash, and green leaves are subjected to a heated air current which wilts the leaves and renders them soft and flexible. The cotton is progressively cleaned as the trash and wilted leaves are extracted from the mixture, without disintegrating the leaves. J. A. Woodruff

Text. Research J. Jan. 1948

Cotton Cleaner

Cotton cleaner. Algernon L. Smith (to Continental Gin Company). U. S. 2,421,526 (June 3, 1947).

This invention is an improvement over a prior patent, U. S. 2,401,439. It is claimed that this improved cotton cleaner is especially adapted for mechanically picked cotton. Cleaning is accomplished mainly by a large cleaning cylinder constructed with a multiplicity of relatively thin discs spaced about $\frac{3}{8}$ in. apart and having serrated surfaces, and a series of small spiked cylinders located above the main cylinder. In operation, the cotton is tossed back and forth between the cleaning cylinder and the spiked cylinders, the rotational directions of which are opposite to each other. Aided by centrifugal force and the spaces between the cylinder discs, the dirt and trash separates from the cotton and falls downward into a reclaiming saw assembly which separates any fiber that may have clung to the foreign material. L. A. Fiori

Text. Research J. Jan. 1948

Cotton Cleaning

Cotton cleaning. Frank E. Deems and Algernon L. Smith (to Contenental Gin Co.). U. S. 2,421,-483 (June 3, 1947).

This apparatus is adapted for separating green leaves and sticks from cotton as it comes from the field. It consists of a row of cleaning cylinders with thin discs spaced about $\frac{3}{8}$ in. apart. These discs are serrated with relatively coarse teeth to aid in moving and agitating the cotton upward. Directly above the cleaning cylinders is a row of spiked agitating cylinders. As the cotton is delivered between the series of cylinders, it is tossed back and forth; thus the trash is separated from the cotton. The trash fall to the bottom of the slanting casing. Several modifications are given.

L. A. Fiori

Text. Research J. Jan. 1948

Elastic Vinyl Fibers

Process for making elastic vinyl copolymer resin textile articles. Theophilus A. Feild, Jr. (to Carbide and Carbon Chemicals Corp.). U. S. 2,428,453 (Oct. 7, 1947).

A process is given for making elastic, resilient textile articles by use of elasticized yarns or fibers of a vinyl resin formed by copolymerization of vinyl chloride and vinyl acetate containing 80% to 95% of vinyl chloride. The elasticizer or plasticizer may be applied to the yarns, fabrics, or fibers directly, from solutions in low- or medium-boiling solvents, or in the form of an aqueous emulsion. Vinyl resin fibers or yarns may be combined with other textile materials to give special elastic effects.

J. A. Woodruff

Text. Research J. Jan. 1948

Inorganic Fibers

Composite textile strand and fabric. Archibald H. Davis. U. S. 2,424,743 (July 29, 1947).

This invention reduces the disadvantageous qualities of the inorganic fibers such as metallic, glass, asbestos, and mineral wool, by the use of organic plastics with the inorganic fibers as the base or core of the yarn. Yarns may be made in a variety of ways, such as plying or twisting together the inorganic and organic fibers or applying the organic plastic directly in discontinuous form to the inorganic core fiber. Fabrics may be manufactured from these yarns by the use of coating compositions. L. A. Fiori

Text. Research J. Jan. 1948

Opener for Fibers

Fluffing up artificial staple fibers. Norma Blanche Geer and Louis William Schatz (to Celanese Corporation of America). U. S. 2,420,367 (May 13, 1947).

This device, by means of a rotary drum faced with pins or nails and operating in a static-free box or bin, provides a process for opening and fluffing up staple fibers—especially

artificial staple fibers—for filling comforters, sleeping bags, pillows, etc. Optimum results are obtained by employing cellulose acetate staple of 1½ in., 3 den. L. A. Fiori

Text. Research J. Jan. 1948

Coated Fabrics

Method of coating fabric with polyvinyl chloride. John Heron McGill and Leslie Budworth Morgan (to Imperial Chemical Industries Ltd.). U. S. 2,428,716. (Oct. 14, 1947).

A base fabric is coated with an aqueous dispersion containing polyvinyl chloride and a plasticizing agent. The fabric is dried and topcoated with a blend of polyvinyl chloride and plasticizer and/or pigments, heated, and cooled. The coated product shows high anchorage between the coating and the fabric. Water-soluble thickening agents may be added to the aqueous dispersions. A calendering operation between the coatings is also helpful. J. A. Woodruff

Text. Research J. Jan. 1948

Resin Impregnated Fabric

Method for manufacture of impregnated flexible fabric. Howard Snow (to Southern Friction Materials Co.). U. S. 2,424,861 (July 29, 1947).

A flexible, water- and wear-resistant product is produced by impregnating a woven textile fabric with a varnish of an oil-modified thermosetting resin, curing the resin impregnant by heating, and then surface-abrading. The abrading gives a slightly napped product which is more flexible than the nonabraded one. J. A. Woodruff

Text. Research J. Jan. 1948

Fabric Straightening Device

Method and apparatus for the straightening of the wefts of woven textile fabrics. Leslie Camden Nield (to Tootal Broadhurst Lee Co., Ltd.). U. S. 2,421,575 (June 3, 1947).

An apparatus which determines when the filling and warp threads are not at right angles to each other and straightens them by means of a

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mechanical device. There are 2 pairs of nip rollers with each pair engaging one selvage of the fabric; an electrically controlled differential motion provides varying circumferential speeds to the nip rollers; 2 contact fingers located at opposite edges of the web just outside the general run of the fabric which operate as electrical starters for the entire mechanism. As the fabric distorts out of line, each nip roller either speeds up or retards its motion until the filling is again interlacing at right angles to the warp.

Text. Research J. Jan. 1948 L. A. Fiori

Flameproofing

Flameproofing of fabrics and composition therefor. Lyman C. Atley and Paul C. Stufft (to Pemco Corp.). U. S. 2,420,644 (May 20, 1947).

The flameproofing composition has as its essential flameproofing agent the fusion product of a metal compound, a refractory constituent containing silicon and a basic fluxing constituent adapted to react with acidic refractory to form a glass. The product described is applied in granular form in combination with oxides, a plasticizer, chlorinated materials, and pigments.

J. A. Woodruff

Text. Research J. Jan. 1948

Flame-Resistant Fabric

Flame-resistant fabric material. Clarence B. White. U. S. 2,427,997 (Sept. 23, 1947).

The use of antimony trichloride as a source of antimony oxide is made possible by impregnating the fabric to be flameproofed with a solution of sodium carbonate and drying before applying the antimony trichloride dissolved in an organic solvent. After the removal of solvent, the fabric is passed through a warm-water solution of sodium carbonate, which forms the antimony trioxide and neutralizes the hydrochloric acid formed at the same time. Glow-resistant compounds are applied at one or more selected stages in the process. J. A. Woodruff

Text. Research J. Jan. 1948

Weaving Plastic Monofils

Apparatus for weaving fabrics of plastic materials. Edward Welti (to Hafner Associates, Inc.). U. S. 2,421,532 (June 3, 1947).

Apparatus for producing firm, smooth fabric from thermoplastic filaments whose stiffness and inflexibility have rendered them impractical for most uses except screenings. When the plastic yarns are preheated to 110° to 120°F they become sufficiently soft and pliable for proper weaving. Heating is accomplished by means of a pair of heating elements, located near the automatic bobbin magazine, and a metallic drum which is part of the warp beam. A modification is shown in which the warp filaments are heated by contact with a special roller arrangement mounted between the heddles and the warp beam. L. A. Fiori

Text. Research J. Jan. 1948

Nub Yarns

Method of an apparatus for producing nubbed yarns. Alexander Cavedon. U. S. 2,421,010 (May 27, 1947).

With this apparatus nubbed yarns may be produced which overcome the difficulties heretofore encountered, whereby the nubs tended to distribute themselves unevenly on the carded web. In this method the nub material, closely resembling the web of carded fibers, is fed in a continuous sheet or lap from a position directly above the card web and between the doffer and condenser. As the continuous lap of nub material approaches the card web, it is cut intermittently, deposited at regular intervals on the traveling web, and carried forward into the condenser, where both the web and overlying cut strips are simultaneously condensed into roving. Yarns having uniformly spaced nubs composed of almost any type of fibrous material that can be formed into a continuous sheet or lap can be produced. The apparatus consists of a lap roll drum driven in unison with 2 feed rolls which, in turn, connect through suitable gearing to a cutting device equipped with a reciprocating blade. As the nub web unwraps from the drum, it is delivered by the feed rolls to the cutting blades, where the web is cut at regular intervals. A modified arrangement for handling a lap composed of extremely fragile and light fibers, such as rabbit's hair, which tend to separate easily, is also shown and described.

L. A. Fiori

Text. Research J. Jan. 1948

Conditioning Warp Yarns

Method and apparatus for conditioning warp, threads, yarns, and the like. Harold J. Walter and Paul R. Rose. U. S. 2,421, 135 (May 27, 1947).

The main object of this invention is to control the moisture content of the warp while it is being woven. Positioned between the whip roll and the loom frame, just below the plane of the warp ends, is a unit distributing conditioned air under pressure through a perforated surface. A plate just above the warp deflects the air passing through the warp and distributes it over a large area of ends. To remove from the air any lint which may have collected through contact with the warp, a modification is shown. The whip roll and warp beam have overlapping hoods so that the air may be collected from the circulating unit and exhausted through a filtering medium. L. A. Fiori

Text. Research J. Jan. 1948

Fluid Treatment of Yarn

Fluid treating apparatus for yarns. Thomas Jackson and Frank Brentnall Hill (to British Celanese Ltd.). U. S. 2,425,037 (Aug. 5, 1947).

Yarn is treated in passing through a substantially closed chamber containing treatment fluid which has an inlet and outlet for the yarn and means for setting up an induced fluid current into the chamber through the inlet. Threading-up is said to be assisted by the induced fluid current. J. A. Woodruff

Text. Research J. Jan. 1948